Volume 7, No. 1 **January 1952**

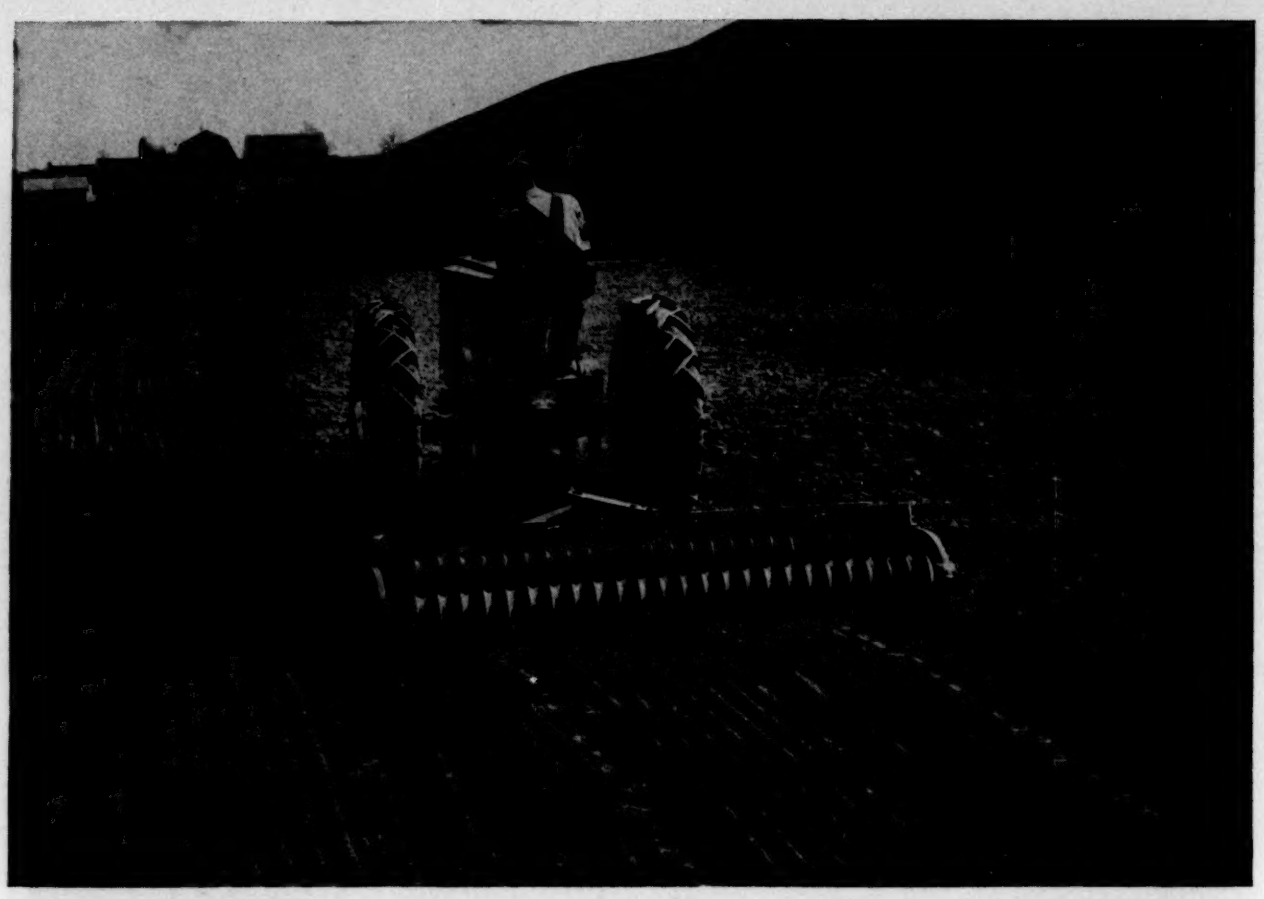
The Economics of Idle Resources

Water in the Southeast

Soil, The Substance of Things Hoped For

Soil and Water Conservation Glossary

Panel Presentation: The Watershed—Using It as a Basis for Soil and Water Conservation



AS GOOD AS A RAIN FROM BELOW

Riding the sky to "seed" rain clouds isn't the most practical way to give newly planted crops a drink between rains.

An older and more dependable way is to put a good mulch on top of the soil, and press out the air pockets below it. Natural laws older than man-made devices begin to operate. They actually pull water up from below to meet thirsty roots or dormant seeds that need extra moisture.

Farmers who use Brillion implements give their soil a "rain from below," for every Brillion implement . . . the Sure-Stand Seeder, Pulvi-Mulcher and Pulverizer . . . leaves a firm mulched seedbed as shown above. It helps speed germination, and improve plant growth and root development — all of which means more money in the pockets of farmers who own and use Brillion implements.

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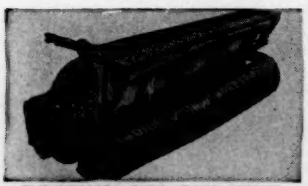

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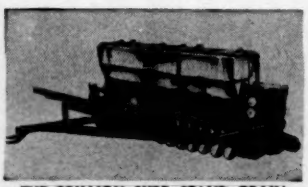

THE BRILLION SURE-STAND GRAIN DRILL. Drills grain, fertilizes, seeds legume and brome, and pulverizes in one operation.

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Thousands of progressive farm implement dealers are in the fight against soil erosion and depletion. An eight-point program for soil conservation cooperation has been organized by the International Harvester Company. This program is designed to help IH representatives and IH dealers work more closely and effectively with their local soil conservation districts.

These IH men are using a handbook prepared by the Farm Equipment Institute and the Soil Conservation Service—*The Farm Equipment Dealer and His Soil Conservation District*—to guide their efforts. They are getting better acquainted with soil conservation leaders and soil conservation projects in their communities. They are using their intimate knowledge of farm machines to figure out faster, easier, lower-cost solutions to soil and water conservation problems with *regular* McCormick farm equipment.

You'll find IH dealers ready and eager to work with you and other soil conservationists. They know that they better serve their farmer customers, their own interest—all America—when they help to maintain the productivity of the soil in their communities.

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International Harvester products pay for themselves in use—McCormick Farm Equipment and Farmall Tractors . . . Motor Trucks . . . Crawler Tractors and Power Units . . . Refrigerators and Freezers—General Office, Chicago 1, Ill.

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The growing emphasis on animal agriculture is building more versatile and more prosperous farms year after year—because animal agriculture best serves the interests of our soil.

As conservationists we know that animal agriculture puts greater importance on pasture and hay crops—for forage, for erosion control and for soil improvement. Animal agriculture also means more and more valuable manure is being returned to the land—both by grazing animals and by mechanical spreading.

In its early championing of an animal agriculture program, NEW IDEA Division of AVCO Manufacturing Corporation is proud to have lent encouragement to a better concept of farm life. Part of our support is to provide forward-thinking farmers everywhere with the time and labor-saving equipment fundamental to soil building.

NEW IDEA, 50 years ago, developed and perfected the first successful manure spreader. Since that time, nearly half a million farmers have chosen NEW IDEA Spreaders as a primary means of keeping their soil in top producing condition.

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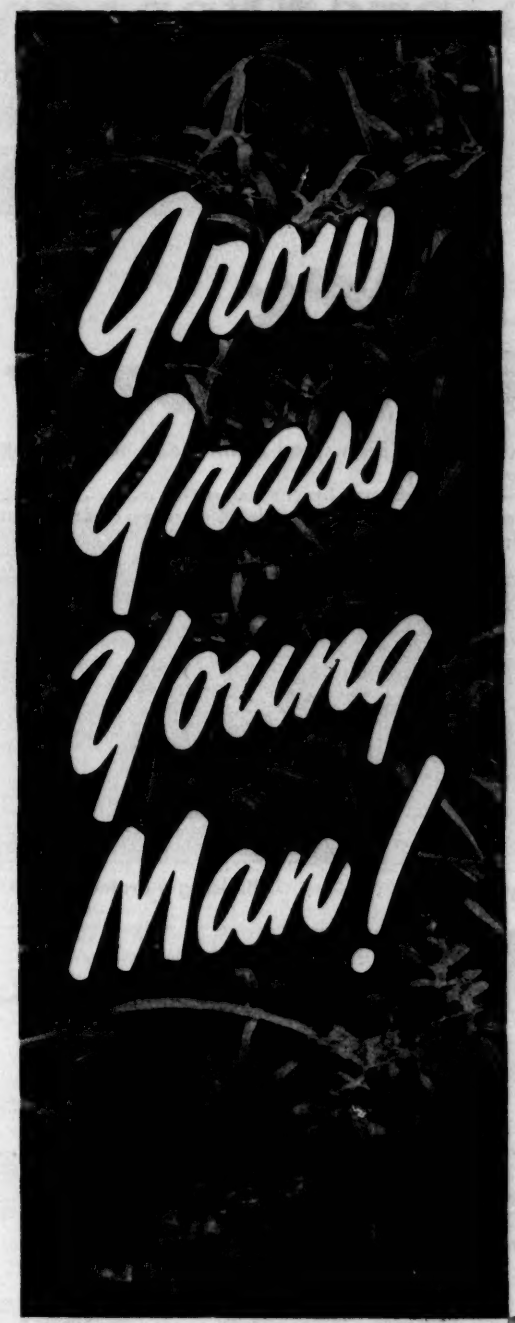


A hundred years ago, Horace Greeley popularized an idea: "Go West, young man, and grow up with the country!" If Greeley were alive today, he might well join the modern refrain: "Grow grass, improve the soil, and increase production."

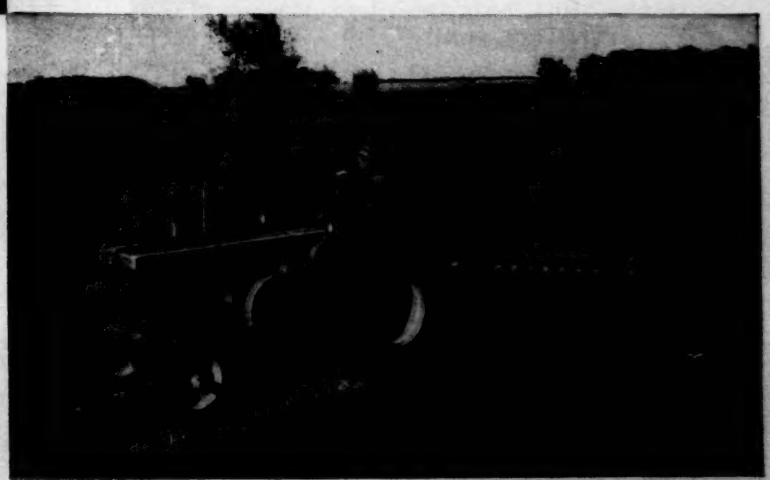
Fitting naturally and logically into soil conservation farming, grass has become one of America's new frontiers. As a nation, we are suddenly aware that grasses and legumes are not only great soil holders but also great soil builders. And, thanks in part to better grass management, we have suddenly realized that grasses and legumes are money-makers, too.

So grass becomes a new frontier—one with lots of room to grow. The U. S. Department of Agriculture reports that of about 1 billion acres now in grasslands, probably not more than 10 to 15 per cent is improved. Yet there is ample evidence that many of these acres could produce up to six times as much as they are now producing.

Thus, history repeats itself. A century ago pioneers were putting sod-busters to endless fields of waving prairie grasses. Today, farmers all over the country are rebuilding grasslands anew. Modern farm equipment makes the job easier, faster, better.

★ ★ ★

BELOW—On a Florida cattle ranch, grass *is put to work.* This tract was once covered with natural browse, rugged but unpalatable grasses, palmetto, briars, and bushes. The scrub was eradicated, the field fertilized and established in highly-productive pasture grasses and legumes. When the picture, below, was made last year, this field was growing a good crop of grass—but not good enough. The owners knew it was time to renovate—a speedy, easy task with modern equipment.



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No single machine will do so many soil conservation jobs so easily, quickly and economically as the Austin-Western Power Grader with its exclusive All-Wheel Drive for maximum traction in rough or soft ground; 30% more "power-at-the-blade" and exclusive All-Wheel Steer for high speed turning and maneuvering in close quarters.

The bulldozer attachment has many uses . . . filling gullies, blocking the ends of level terraces, clearing out brush and small trees, to mention a few.

Constructing a diversion ditch

Shaping a waterway

Building a drainage ditch

Cutting a V-ditch

Spreading a spoil bank

Ditching for drain tile

Building an outlet ditch

Filling a gully

Clearing brush

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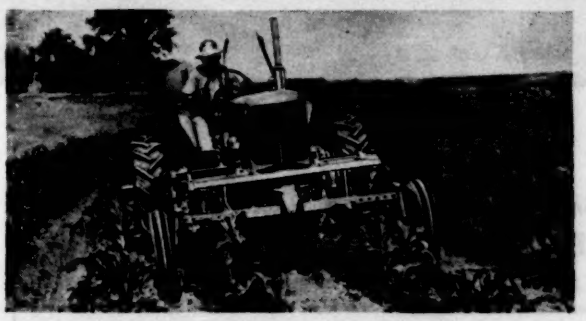
GRASSROOTS SOIL CONSERVATION

Mounted plow for the WD Tractor is free-swinging — follows naturally around contours. Uniform movement of dirt — easy to control with this tractor and plow — builds good terraces.

Vision, clearance and hillside stability are combined in one cultivating outfit for easy handling on contoured hillsides. Soil conservation work need not take longer.



The CA Tractor with mounted drill planter does an accurate job of planting on the contour. The tractor *leads* the planter around the slope — assures uniform row spacing where rows curve.

Soil conservation has moved out of the talking stage and into the everyday habits of almost a million farmers. Even a quick through-the-windshield survey shows the new attention being paid to contour farming, grassed waterways, terraces and efficient drainage of wet land.

The progress that has been made is encouraging, but soil conservation workers know that it is only a start. In organized soil conservation districts farmers learn how to apply many types of land-saving practices. But the rate at which they shift to this new farming pattern is often limited by the extra time and labor required to make both surveys and the needed changes in land use.

Soil saving and time saving go together with the right power equipment rightly used. Allis-Chalmers WD and CA Tractors use engine power in more ways than ever before — to increase traction for such jobs as subsoiling and building terraces, to space rear wheels to fit each job, to operate power take-off equipment independent of tractor motion.

Most recommended soil conservation practices can be carried out effectively with modern home-owned power equipment. Tractors such as the CA and WD can be the key to wider acceptance of the new farming pattern.

ALLIS-CHALMERS
TRACTOR DIVISION • MILWAUKEE 1, U. S. A.

Journal of SOIL AND WATER CONSERVATION

VOLUME 7
NUMBER 1

TO ADVANCE THE SCIENCE AND ART OF GOOD LAND USE

This JOURNAL is the official organ of the Soil Conservation Society of America. It is owned, edited, and published quarterly by the Society.

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PUBLICATION OFFICE: 32nd Street and Elm Avenue, Baltimore 11, Maryland.

NATIONAL HEADQUARTERS AND SECRETARY'S OFFICE: Suite 1016 Paramount Building, Des Moines 9, Iowa.

POST OFFICE ENTRY: Entered as Second-Class matter in the Post Office at Baltimore, Maryland, August 28, 1946, under the Act of March 3, 1879.

MEMBERSHIP: Annual membership is on a calendar year basis and is $5.00 per year for members and $3.00 per year for associate members, of which $1.50 is for subscription to the JOURNAL and 25c for NOTES AND ACTIVITIES. Subscriptions for the JOURNAL to libraries and others is $3.00 per year. Single copies are 75c each.

CORRESPONDENCE—Concerning manuscripts, books for review and other editorial matters should be sent to the Editor, Room 303, Watson Building, Fairmont, West Virginia.

BUSINESS CORRESPONDENCE—Concerning remittances and questions should be sent to the Executive Secretary, Suite 1016 Paramount Building, Des Moines 9, Iowa.

CHANGE OF ADDRESS: Notice of change in address should be received two weeks before the date of issue on which the change is to take effect. Both the old and the new address should be sent to the office of the Secretary.

REPRINTS: Articles appearing in this publication may be reprinted on condition that full credit be given the JOURNAL OF SOIL AND WATER CONSERVATION and the author; also the date of publication.

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COVER: A stand of virgin hardwoods on Claremont silt loam soil in Jennings County, Indiana. The soil is poorly drained and for the most part level. When cleared of tree growth and cultivated, the finer soil particles filter down to plow depth creating a hard pan which prevents all movement of soil water. Because of these factors, this land should remain in woods.

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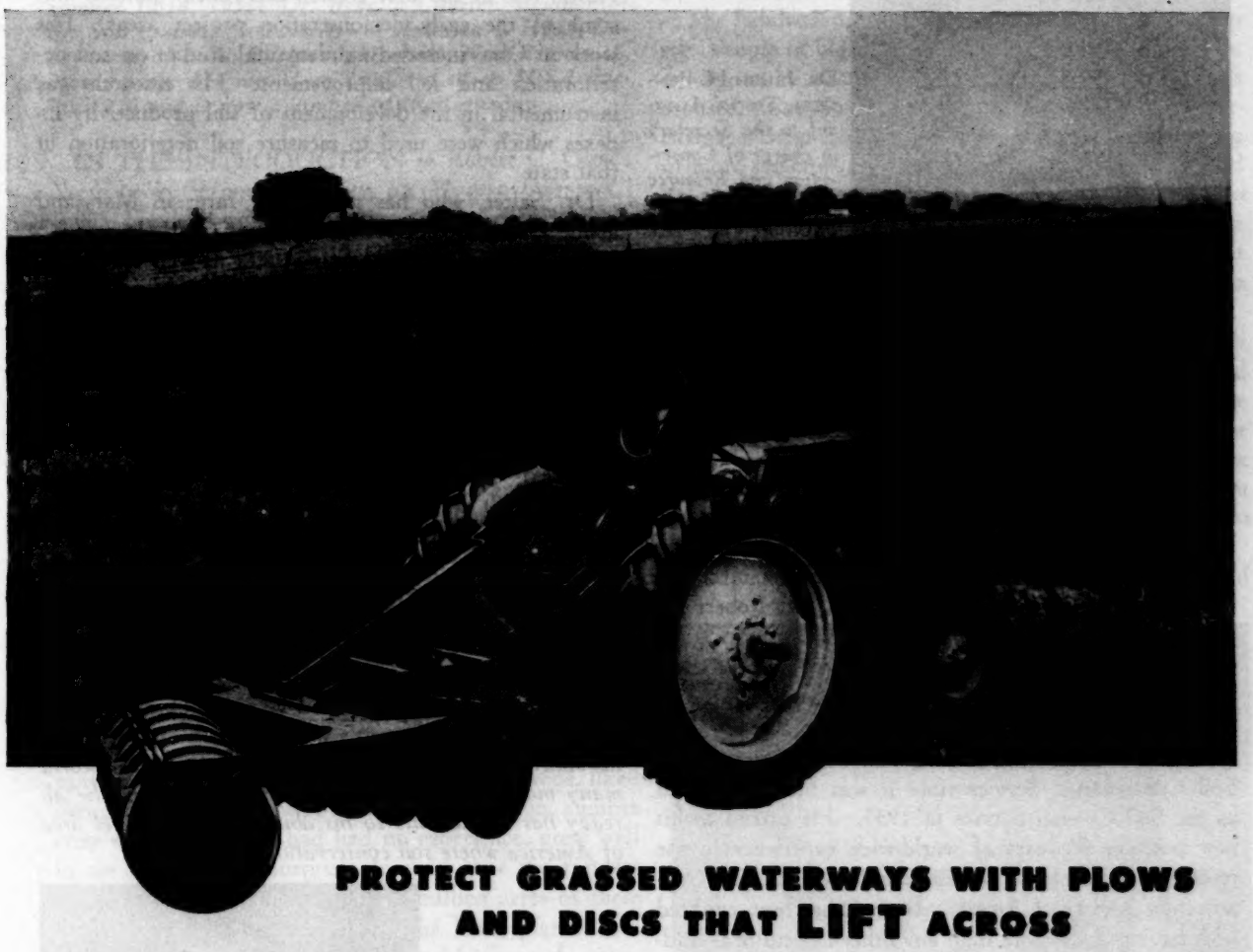
TOOLS THAT HELP YOU PROMOTE BETTER FARMING



PROTECT GRASSED WATERWAYS WITH PLOWS AND DISCS THAT LIFT ACROSS

It is one thing to seed and establish grassed waterways . . . quite another to have the field tools that will protect these waterways. Massey-Harris has them.

Shown above, for example, is a Massey-Harris heavy duty Goble mounted disc that can be raised and carried across the waterway . . . avoids tearing up the turf. Similarly, mounted plows for the Massey-Harris Tractor can be lifted and carried across grassed waterways — without even so much as slowing down the tractor. For pull-type discs, plows, heavy-duty field cultivators a Massey-Harris remote hydraulic control can be installed to straighten and angle the discs while "on the go" — as well as lift the equipment.

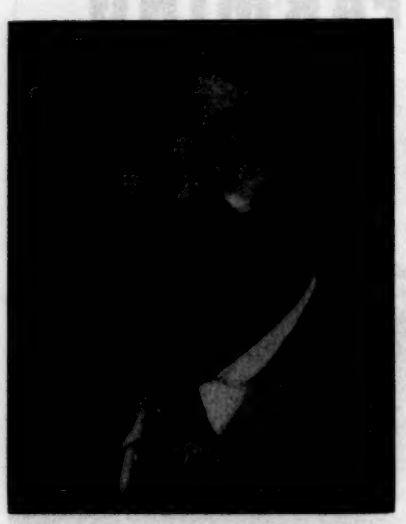
These are just a few examples of how Massey-Harris tools help you promote soil conservation. It shows that we must all work together to HELP SAVE OUR SOIL. The Massey-Harris Company, Quality Avenue, Racine, Wisconsin.

Make it a Massey-Harris

MASSEY M+H HARRIS

EVERY AGRICULTURAL ENGINEER HAS A STAKE IN SOIL CONSERVATION

Hugh Bennett to New Job; Salter Takes Over as SCS Chief



DR. HUGH H. BENNETT, *Special Assistant to the Secretary in charge of Conservation and Resource Matters; also* FOUNDER OF THE SOIL CONSERVATION SOCIETY OF AMERICA

A move of major interest in the field of soil conservation was made on November 15 when Dr. Hugh Hammond Bennett moved up to a new position as special assistant to the Secretary of Agriculture in charge of conservation and resource matters. Dr. Robert M. Salter, Chief of the Bureau of Plant Industry, Soils and Agricultural Engineering, was named to succeed Bennett as Chief of the Soil Conservation Service.

Dr. Bennett—"Big Hugh" as he is known by many throughout the United States, had been Chief of the Soil Conservation Service since it was first established as the Soil Erosion Service in 1933. He carries to his new position 48 years of world-wide experience in the resources conservation field. Founder of the *Soil Conservation Society of America,* Bennett has been credited with having done more than any other agricultural leader to promote soil conservation in the world.

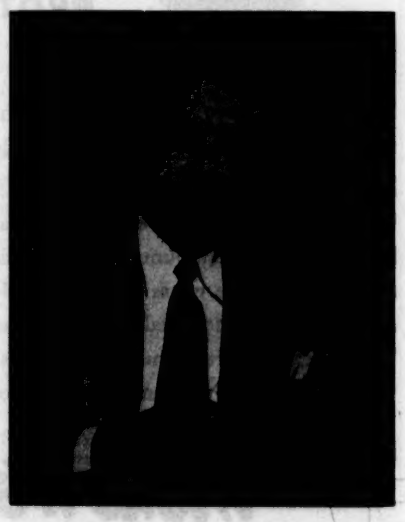
His successor, "Bob" Salter, is no newcomer to the agricultural scene. In his 35 years of experience in crops, soils and related agricultural fields, Dr. Salter has worked closely with soil conservationists and has given attention to that program throughout his career.

Starting in 1915, he spent six years with the West Virginia Experiment Station as a soil chemist and later as an agronomist. Then he went to Ohio as extension agronomist and professor of soils. From 1925 to 1940 he was in charge of crops and soils at the Ohio Agricultural Experiment Station.

During his last two years at Ohio, he was associate director of the station. And, as director of Ohio's soil research, he helped the Soil Conservation Service establish one of the first erosion experiment stations and some of the early demonstration project areas. His work in Ohio included fundamental studies on soil deterioration and soil improvement. His research was instrumental in the development of soil productivity indexes which were used to measure soil deterioration in that state

Dr. Salter, who has a 150-acre farm in Maryland about 35 miles from Washington, brings to his new job a reputation as a good administrator as well as a scientist. His first public appearance as Chief of the Soil Conservation Service was made at the annual meeting of the Soil Conservation Society of America at Memphis, November 13. In a short talk during the banquet program, Dr. Salter pledged himself to carry forward the principles on which the present national soil and water conservation program is conducted. Following that meeting, he left on a nation-wide tour to acquaint himself with more of the SCS work and employees throughout the country.

The beloved Hugh Bennett, who at 70 has given up active leadership of the agency he headed since its beginning, is by no means forsaking the cause to which he devoted his life. In announcing the appointment, Secretary Charles F. Brannan said he was looking forward to the use of Dr. Bennett's wide and rich experience on his staff. *"I hope that Dr. Bennett will give the world many more years of his talents and energy, but he already has monuments to his ability in every rural area of America where soil conservation is practiced."*



DR. ROBERT N. SALTER, *Chief, U.S. Soil Conservation Service*

Soil, The Substance of Things Hoped For

FIRMAN E. BEAR

This paper by Dr. Firman E. Bear was presented as the principal address during the banquet at the Sixth Annual Meeting of the SCSA held in Memphis, November 12-14, 1951. Dr. Bear, a Charter Member of the Soil Conservation Society of America, is Head, Department of Soils, Rutgers University, New Brunswick, New Jersey. He served as President of th SCSA during 1950 and is now a mmber of the Council.

IN THE INTRODUCTION to Robert C. Cook's recent book, *"Human Fertility, the Modern Dilemma,"* Julian Huxley writes that "human population is probably the gravest problem of our time—certainly more serious in the long perspective than war or peace."

Cook points out that world population, now estimated at 2½ billion, is increasing at the rate of 68,000 every 24 hours. This is equivalent to 25 million a year. The rate of population growth in the United States is higher than the average for the rest of the world.

When Captain John Smith first set foot on the shore of Virginia in 1607 the 1,903 million acres of land that now constitute the United States of America was inhabited by some 800,000 Indians. Each of these Indians had 2,400 acres of land at his disposal. Today, only 344 years later, our population is over 150 million and the amount of land for each person has been reduced to 12 acres. Over half of this is desert, mountain, lake, and swamp.

Previous to their coming to America our European ancestors had never seen corn, potatoes, tobacco, peanuts, or tomatoes. They tasted these Indian crops, liked them, and soon set about growing them. Cotton, another crop with which they had had no experience, grew well in the South. In a surprisingly short time the farmers of this country were growing 150 million acres of these crops every year. They plowed the land, planted the crops in long straight rows, cultivated between the rows, and developed the most destructive type of agriculture the world has ever known.

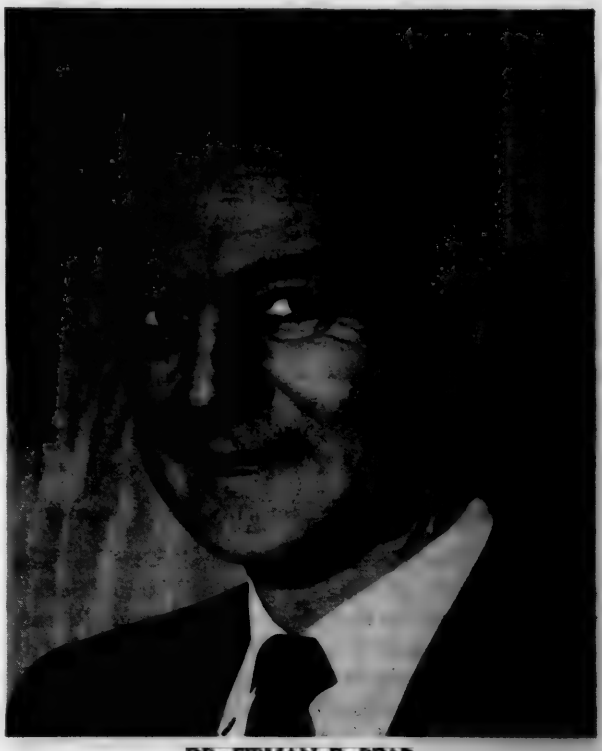
Public Sentiment Was Aroused

Our people are mechanical minded. The 2,000 tractors of 1910 grew to 3½ million faster-moving types by 1950. The horse and mule population fell from 25 million to 7½ million. Fences, the Maginot line against erosion, were torn out to make more room for the tractors. This gave the wind and water a longer sweep. As a result millions of tons of good topsoil were carried down the slopes and dumped into the rivers. Mud clogged the harbors. Silt poured into the reservoirs, reducing their storage capacity from one to three per cent a year. And dust storms tore the soil loose from its moorings in Kansas wheat fields, spread it over the country to the east, and carried some of it on out to sea.

The handwriting of erosion was plain for everyone to see. People in high places began to be cognizant of the damage that was being done. Public sentiment was aroused. The Soil Conservation Service came into existence. Strip-cropping, contour-farming, the growing of more sod-crops, the seeding of more cover crops, and the planting of forests got under way. Farmers began to realize that it was necessary to take greater advantage of roots as a means of sewing the soil to the earth. But millions of acres of good land had been ruined before this came to pass.

In 1607 virtually all the land east of the Mississippi River, except for the prairies of northern Indiana and Illinois, was covered with forest. A squirrel could have gone from Maine to Louisiana without touching the ground, merely by jumping from one giant tree to the next. These trees were in our way. So we cut them down, burned them up, laid bare the land, and put it to the plow.

Judging by the luxuriance of these forests, one would



DR. FIRMAN E. BEAR

have thought that the soil beneath them was highly productive. For the moment, it was. But once the trees had been cleared off and the soil had been brought under cultivation a large part of the accumulated organic matter was soon used up. Then we discovered that the underlying soil had lost virtually all its soluble substance to the sea. Limestone, phosphate, and potash salts had to be supplied. Last year American farmers bought and applied nearly 50 million tons of these soil amendments. This is enough to fill a line of 40-ton freight cars extending nearly four times the distance from New York to San Francisco.

The farther west one goes in the United States the less the rainfall and the smaller the amount of soluble material that has been washed out of the soil. In the desert areas soils are highly productive, once irrigation has been applied. Some 25 million acres of desert land is being irrigated, and there is water for some 20 million more. East of the 150 million acres that constitute the Great American Desert is a 600 million-acre area of semi-desert, with a rainfall of 10 to 20 inches. Some 300 million additional acres is contained in the subhumid portion of the Great Plains. All these regions need water rather than lime or fertilizer.

Farther east a vast area of rich black soil extends from the Dakotas south to Texas. This land needs phosphate and potash, but not lime. East of this black-land area, where the rainfall is still heavier, both lime and fertilizer have to be used in large amounts. Over 75 per cent of the world's food comes from such humid areas. By and large, it is easier to haul the necessary salts back from ancient seas and put them on the land from which they came than it is to provide the much larger tonnages of water that are required to bring more of the desert under production.

But the problem of maintaining adequate supplies of nutrient elements in the soils of humid regions becomes more and more troublesome as the years go by. Virgin fertility has largely been exhausted. We are no longer satisfied with the yields that unaided Nature can provide. The modern goal is 100 bushels of corn, 50 bushels of wheat, 500 bushels of potatoes, 20 tons of tomatoes, and five tons of alfalfa hay an acre.

Deficiencies in Trace Elements Are Common

As the soil becomes older agriculturally and the yields are stepped up by growing improved hybrids and disease-resistant varieties, by using improved tillage implements, and by applying more lime and NPK fertilizer, other deficiencies develop. In certain areas magnesium must be supplied. In other areas sulfur is needed. Under some circumstances iron deficiencies develop. In still others the limiting factor in plant and animal production is a lack of boron, molybdenum, copper, manganese, zinc, cobalt, or iodine. These last seven minor elements present some of our most troublesome problems.

Take boron, for example. Over 12 per cent of the soil of New Jersey is known to be in need of this element for maximum productiveness. Field tests with alfalfa have shown that a 25-pound application of borax an acre may make all the difference between success and failure. It is not uncommon to be able to increase yields of hay as much as one ton an acre by applying 75 cents'-worth of borax.

More recently we have been intrigued by the possibility of widespread need for molybdenum. In the beginning phases of our work on this element on alfalfa we had great difficulty developing a deficiency in plants grown in sand culture. Finally, by redistilling the water and recrystallizing all the nutrient salts, deficiency symptoms were developed in sand cultures. The plants stopped growing and turned yellow. But all that was required to start them on again was one part molybdenum in one billion parts of the nutrient solution. Yet during the past year a New Jersey vegetable grower plowed under 45 acres of cauliflower that couldn't produce heads because the soil lacked available molybdenum.

The soil of this great land of ours is capable of producing food in abundance for possibly one billion people. Hopefully, there will never be that many people to feed. But if the time comes that there are, much more of the total expendable budget will have to be invested in food. Some outlying land will have to be reclaimed from the sea. Additional water for irrigation will have to be distilled from the ocean. Tremendous tonnages of lime and fertilizer will have to be used. Floods will have to be brought under complete control. The soil on every acre of land will have to be conserved. The problems of growing enough food for all these people will be very serious ones. We will have to be satisfied with less meat and more bread, potatoes, and vegetables. Some of our less fortunate folks may go to bed hungry, as do millions of people every night in the more densely populated parts of the earth.

The Soil Conservation Society of America is dedicated to the task of conserving the nation's soil, water, and life resources to the end that, whatever the final population may be, the issue can be met. It feels under obligation to leave no stone unturned to the end that our land is conserved and its productivity is not only maintained but raised to ever higher levels. Its aim is to see to it that our increasing numbers of fine young folks continue to enjoy the fruits of the earth in abundance.

Panel Presentation

The Watershed—Using it as a Basis for Soil and Water Conservation

Getting the Facts Through Surveys and Investigations

H. E. HUDSON, JR. and J. B. STALL

Collecting basic data on soil and water resources is the starting place in project design. The watershed is a natural "water handling" unit and has important advantages as a basis for collecting and analyzing facts. Recurring measurements are necessary for most hydrologic facts. Non-recurring measurements are suitable for land facts with noted exceptions. A continuing program of study of reservoir sedimentation in Illinois has shown the effect of human activities on the transport of sediment by water. Local, state and federal agencies must collaborate to insure well-rounded programs of data collection. Illinois' experience proves these people can work together effectively.

THE LAWS OF NATURE govern the effective conservation and development of our land and water resources. These laws are not limited by the boundaries of a valley authority, a conservancy district or a watershed boundary.

A watershed is generally considered to be the geographic area of overland drainage which contributes waters to the flow of a particular stream at a chosen point. It is a "water collection" and "water handling" unit, a topographic entity which is usually surrounded by other entities of the same nature.

A great river basin consisting of an entire region drained by a major continental river and its tributaries is a comprehensive mass of variable facts, but the watersheds within the basin are frequently small enough and homogeneous to let us gather all the facts, correlate them, understand the applicable laws, and intelligently design and build successful conservation developments. We cannot do an intelligent basin-wide job until we understand the functioning of the watersheds within the basin.

The drainage area is a natural unit in the important runoff phase of the hydrologic cycle. It should be noted however, that other phases such as evaporation, rainfall, and the occurrence of ground water do not necessarily follow drainage area boundaries. For instance the rainfall pattern in Illinois is affected less by the low divides which enclose the Illinois River basin than it is affected by the climatic change between northern and southern Illinois.

Water conservation programs may be aimed at conserving energy, as in reducing floods, or generating hydroelectric power, both of which generally aid in increasing the minimum stream flows; or they may be aimed at conserving materials, such as programs for reduction of pollution or reduction of silt load. Soil conservation programs are aimed primarily at conserving material through preventing physical loss of soil and fertility; and toward maintaining high crop yields.

Soil and water conservation programs that will stand the test of time require decisions based on facts on the physical situation. Getting the facts therefore is fundamental to every conservation program, and to enable good program planning, fact collection should be as complete as we can make it. The cost of gathering the basic data on water and soil resources is small in comparison to project costs but only the facts can enable design in compliance with nature's laws.

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This paper was presented at the Sixth Annual Meeting of SCSA held in Memphis, November 12-14, 1951.

There are two general kinds of fact collection: Recurring, and non-recurring. For things that change rapidly we need extended programs of repeated measurements.

Water Resource Facts

Since water resources are renewable, they require extensive collection of recurring measurements. In a particular region there is need for long-time recording of intensity and duration of precipitation and for data on the character of the more intense rainstorms. These are intimately related to erosion and flood problems.

Meteorologic data are usually available over a longer period of time than other hydrologic data. The cost of collection of precipitation data is comparatively low. Frequently long-time precipitation records are highly valuable in extending stream-flow records or other records which are available in more detail but for a shorter or interrupted period of time.

Stream-gaging within the watershed is essential for estimation of sediment transport as well as for design of water projects. Closely related to stream flow gaging is the measurement of sediment transported in the streams, for sediment concentrations must be correlated with the volume of stream discharge to learn the total quantities of sediment transported. A fairly complete program of stream-flow gaging has been developed in this country since the turn of the century by the United States Geological Survey. Such gaging stations are generally operated on a matched-funds basis with the state or local agency contributing half of the cost of the work. About 170 stations are now in operation in Illinois or on its boundaries and 11,370 in the entire 48 states.

While the measurement of meteorologic and surface water phenomena progresses, there is need to gather information on ground water conditions. These include studies of the waterproducing formations, the availability of ground water, and the relationships of ground water occurrence to surface and meteorological waters. At the same time it is important to make frequent analyses of water quality, both underground and in the streams, to determine chemical characteristics.

A good deal may be learned from stream flow records. For example, recent Water Survey studies on the contributions of overland (runoff) flow to streams as compared with ground water discharge indicate that nearly two-thirds of the annual stream flow in Northern Illinois came from groundwater, while in Southern Illinois less than ten per cent of the stream flow passed through the earth.

Data on two extremely large factors in the water cycle, evaporation and transpiration, are gravely needed. Losses due to evapo-transpiration are commonly greater than the stream flow. Data on these factors are scarce due to the lack of adequate methods of measurement; yet in many cases, the success or failure of a watershed conservation program may be determined by adequate knowledge of these items.

The recurring measurement of hydrologic information requires cooperation of the state or local agency with many other agencies such as the U.S.G.S., which carries on stream-gaging work, the U.S. Weather Bureau, which does extensive climatologic data collection, as well as with many others. The Illinois Water Survey has been in this particular field of activity for some fifty-six years, and its program is therefore fairly extensive. Its present program includes studies of precipitation with radar, an extensive program of collection of ground water data, and a sizable program of water quality determination.

Other water resource information must be collected on a non-recurring basis. This includes some of the ground water data for, except where the works of man intervene, ground water situations change slowly and may be studied on a non-recurring basis, or with a recurrence interval of many years. There is need for mapping of stream channels, reservoir volumes, land slopes, and of other slowly-changing things. In general, these latter measurements may be carried on at intervals not more frequent than once in ten years, if that often. For example the first survey of Lake Decatur was made in 1931. Subsequently a detailed survey was made in 1936, and another detailed survey in 1946.

Land Resource Facts

Changes in the land are less rapid than those that take place in streams, and data need not be obtained so often. For example, the frequency of soil mapping may be determined by the development of improved classifications rather than by changes in the soils. Measurements of the soil resources that are necessary to the planning of any watershed program include mapping of the distribution of soils, slopes and erosion, studies of the character of the soils in the basin, investigation of subsoil conditions, and identification of sediment sources, either by inspection of the land or by analyses of accumulated sediments.

One method of determining the rate of erosion and the amount of sediment which is being transferred from the land into the river waterways is by measurement of sediment deposits in reservoirs. The Illinois State Water Survey has been active in this field for more than 20 years. All its work is carried out under a cooperative program involving all the major agencies which have information of value in relation to sedimentation.

The Illinois program of sedimentation study includes field work in measuring the actual amount of sediment

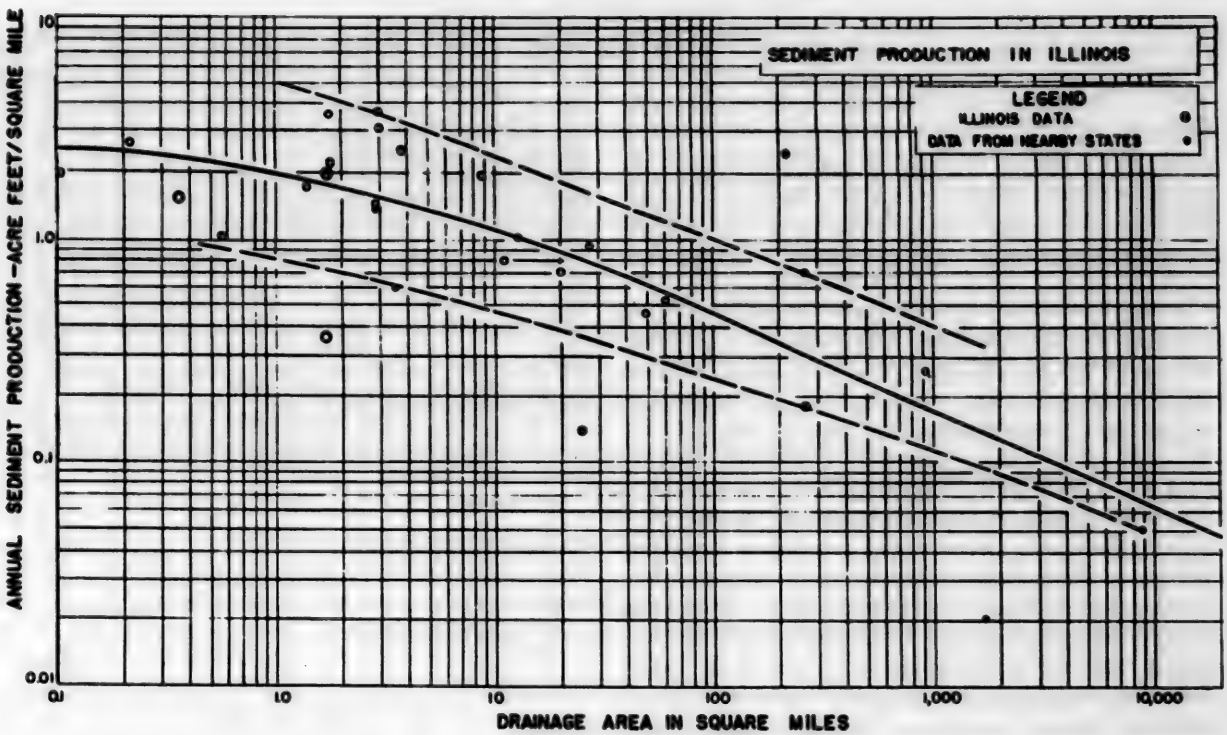

Figure 1. Sediment Production in Illinois.

accumulated in reservoirs, and in compiling the hydrologic and engineering facts relative to each of the reservoirs. The lake owners provide records of construction, modifications, and use, and furnish labor to aid in the actual surveys. The Office of Research, Soil Conservation Service, contributes technical advice and guidance and furnishes equipment for some of the work.

Cooperating in the studies, the Soil Conservation Districts within the counties, and State and Soil Conservation Service soils surveyors work on the collection of data on the erosion on the land. The data include a complete or sample conservation survey of the watershed for each reservoir surveyed, involving location of eroding areas, extent and degree of erosion, slopes of land, and soil groups involved in the erosion process. The Agricultural Experiment Station of the University of Illinois analyses samples of sediment taken during the engineering survey of the lake to determine the character of the sediment.

Under the cooperative program, data are now available on 41 reservoirs in Illinois. Detailed surveys have been made on 18 reservoirs; reconnaissance surveys on 17. Preliminary cross-sections have been taken on six new reservoirs during construction.

The Illinois reservoir sedimentation program has not yet determined all the separate effects of the many physical factors involved in soil erosion and sediment movement. Certain general relations have evolved, however, as shown in Figure 1, which summarizes the Illinois data. From this graph it is seen that the contribution of sediment into reservoirs from small watersheds is greater per square mile than the amount of sediment that arrives in reservoirs which receive the flow from large watersheds. Large watersheds do cause more reservoir silting than small ones, but the silting is not in direct proportion to the area. Part of the sediment drops out of the flow of water enroute from the point of erosion to the reservoir. The average annual rate of sediment production on the smallest watershed studies is in the neighborhood of three acre feet per square mile, which checks reasonably well with a mean figure of seven tons of sediment per acre, estimated by studies on the land.

Certain facts in connection with the soil do need to be measured fairly frequently. Land use changes rapidly at times and frequently brings about changes in erosion rates. The Agricultural Experiment Station, in cooperation with the Soil Conservation Service, has collected information on the land use history of each basin. The latter has undergone marked changes with resulting changes in erosion rates.

At Lake Decatur, the intensive war-time cultivation of corn and soybeans apparently increased erosion rates. A survey of this lake showed that during 1922-1936 the lake had lost capacity to sediment deposits at a rate of

1.0 per cent per year. A later survey showed that during 1936-1946 this rate had increased 20 per cent to a loss of 1.2 per cent per year. Analysis of stream flow data indicated that the difference was not due to climatic or hydrologic factors. A study of land use data in the watershed showed a 29 per cent increase in the acerage of clean-tilled crops—corn and soybeans. The higher erosion rate on such fields was concluded to be the chief factor in causing the increased lake sedimentation.

From Figure 1 we have estimated the sediment load reaching the Illinois River. The sewage and waste suspended solids discharged by the population and industries along the river add up to about only one-thousandth of the sediment load caused by erosion.

Facts on Human Activities

Collecting data on human activities in the watershed is much like market research. It is necessary to determine present and future demands that may be placed on the resources available, such as demands for food and fiber, and for industrial products. If for example it were anticipated that population would dwindle, it would follow that less intensive cultivation would be required, and less intensive development within any particular watershed would be expected except where the local conditions were exceptional.

Many economic and human aspects need to be evaluated. Do the people in the basin have the capital necessary for the completion of the proposed development? Have they learned to desire the contemplated developments? Is there desire or need for immediate cash crops greater than their desire for long term improvements of their conditions? What proportion of the farms in the basin are occupied by owners? What are the customs of the area that may make it difficult to initiate the projects under consideration?

The avowed purpose of the soil conservation movement is the "most productive use of each acre of land in accordance with its capabilities." In the arid regions of this country it has become equally important to "make the most productive use of each gallon of water." Here the presence of water is the major controlling factor in the capability of the land.

In states like Illinois where water is not yet the controlling factor in agricultural production, it may nevertheless become critically important. Furthermore, a development plan for water resources is necessary that municipalities and industries, supported by agriculture, may thrive. Table 1 gives the story of demands that are placed on water in Illinois. This method can be applied in any watershed.

Notice the importance of industry as a producer of wealth and as a water user. Agriculture generally uses water that does not appear as stream flow; in Illinois this is 76 billion gallons daily, of which agriculture is using about 33 billion gallons daily. Industry and the cities use only the "available" water that appears as stream flow, and they are using nearly half of that. These latter uses can be reduced by effective conservation measures, but Illinois is much closer to the danger point in municipal and industrial uses than in agricultural ones.

Table 1. Status of water resources and water use in Illinois—1948.

Item	Billion Gallons Per Day	Annual Value Millions of Dollars
Atmospheric Moisture passing over Illinois	2,000	------
Precipitation	99	———
Transpiration by Crops	33	1,983
Evaporation losses, etc	43	0
Stream Flow	23	———
Industrial Use	8	6,675
Municipal Use	1	40

Erosion has a serious effect on the industrial potentialities of any watershed. High concentration of turbidity in the river makes the water undesirable for use in industrial processes through increased fouling of condensers and through making the water less suitable for other uses. In addition, the deposition of sediments along the valleys beneath the flowing streams have created a situation where recharge of water from the river into depleted ground water formations adjoining is much reduced.

Such a situation has developed at Peoria. Ground water levels in 1933 were generally higher than those in the river. The heavy industrial pumpage from wells which has grown in the last few decades at Peoria has resulted in a lowering of ground water levels to the point where, in much of the Peoria region, ground water levels are now far below the level of the water in the river. In most situations it is expected that the creation of such a situation will lead to discharge of water from the river into the ground, but this happens to only a very small extent at Peoria so that the ground water deposits in this region must depend primarily on the water entering them from other sources than the Illinois River. Thus the sediment in the river exerts a marked adverse effect on the availability of ground water for industrial use.

To overcome this situation the Water Survey (in cooperation with the local Association of Commerce) now has in operation at Peoria a pilot ground water recharge pit (Figure 2) capable of recharging directly the ground water formations with river water at a rate of about two

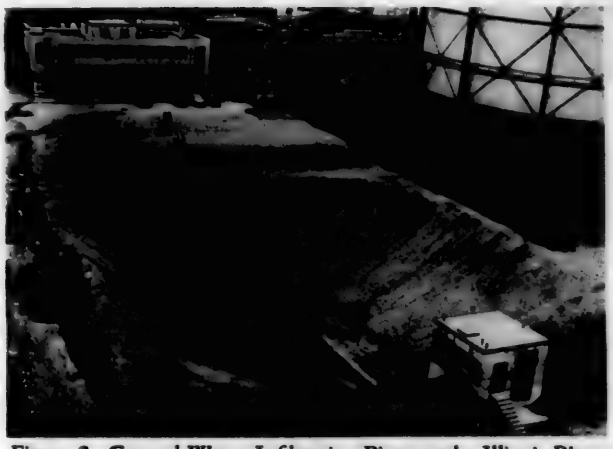

Figure 2. Ground Water Infiltration Pit near the Illinois River at Peoria.

million gallons per day. However, even the operation of this pit is subject to the vagaries of the river. Recharge can only be carried on when temperature and turbidity of the river water are low. Dr. Max Suter supervises this work.

It would seem that the greatest weakness in the Illinois program has been in the field of collecting and using information on the attitudes of the people, their economic resources, and the other human and economic factors that may either favor or handicap development of water projects. Much basic information on the economic aspects has been gathered by Elmer Sauer but so much difficulty is being met in carrying projects to completion under local sponsorship that we believe we know too little about human aspects to motivate people to act on their own problems.

Understanding the Facts

We learn nature's laws from analysis of the facts. We cannot use the facts we gather unless we understand their significance. And frequently we cannot know what facts we need without attempting to interpret the data available.

Nearly 20 years ago, two lakes were built in northwestern Illinois. One lake, of 800 million gallon capacity, was built in 1923 by a railroad to furnish a water supply. The drainage area was nine square miles and a 1949 survey showed the lake had lost 14.3 per cent of its original capacity in 25.6 years. Through the years a country club has developed the lake area under a long-time agreement with the railroad. The clubhouse enjoys an extremely delightful setting on the lake bank. Fifty or more private cabins, as well as group camp sites, have been constructed. The 18-hole golf course is the pride of the club members. The club anticipates many future years' use of these recreation facilities.

About the same time, another lake was constructed, located not 50 miles away. Here, similar cabins and a clubhouse were developed over the years since the lake was constructed in 1924. Here, a lake of 87 million gallons capacity was constructed on a drainage area of 13 square miles. Our survey of the lake in 1947 showed it had lost 73.6 per cent of its capacity to sediment in its life of 22.9 years. Water near the dam was formerly eight feet deep. This was reduced to two feet by sediment. The spillway of the lake failed in 1950 draining the lake. The beautiful clubhouse is now practically useless. This watershed was much too large to serve the size of the lake which was built. In our report on this lake we seriously suggest to the lake-owners that due to the exorbitant rate at which sediment is arriving in the reservoir, that the club abandon the lake at this site. The lake basin shown could surely be worked into a nice golf course and further expenditures toward prolonging the lake would be saved.

The bright and dismal futures of these two comparable recreational developments certainly present a contrast! The difference is believed to be a case of good luck in the first case and poor luck in the second. At the time these lakes were constructed, there were not available the facts and the understanding that we now have at our disposal. One turned out favorably and one badly. With the understanding that existed at the time of designing the cases might as easily have been reversed.

In reservoir design, the ratio of the lake capacity to the watershed area is of paramount importance. Where an exorbitant rate of storage loss occurs the watershed is probably too large for the lake. Even in cases where soil loss from the cultivated fields is reduced to the minimum, the presence of a disproportionately large watershed results in excessive sedimentation. Carl B. Brown's work on this subject is fundamental. The relationship of lake capacity and land area brings out the importance of watershed thinking in project development.

Conclusion

To plan and carry out soil and water conservation programs we need much factual information on hydrologic, land resource, and human situations. Some of the data must be collected continuously and this work requires stable programs for fact collecting. The collaboration of specialists in the fields of hydrology, agronomy and economics, and of local, state, and federal agencies, is important to ensure well-rounded programs. Illinois' experience demonstrates that these people can work together effectively. Getting the facts together is only part of the job; we must then correlate them and try to understand the natural laws that interrelate them. When we have done this, we are ready to begin planning for soil and water conservation programs.

Planning the Watershed

CARL B. BROWN

ALMOST EVERYONE AGREES that sound plans are essential to constructive action in most lines of endeavor. Certainly we wouldn't build a modern house without detailed plans. But one of the most essential types of planning—community watershed planning—is a missing link in our going national land and water resource programs.

Successive stages in the unfolding of any public enterprise are: 1) Formulation of a policy; 2) Development of a program; 3) Preparation of a plan; 4) Drafting of designs and specifications; 5) Application, installation or construction; and 6) Operation and maintenance. It is unfortunate that in this logical succession, programs and plans are often confused. The term "program" comes from the Latin word meaning "a public proclamation or manifesto." "Plan" comes from the Latin word meaning "flat or level," hence a representation projected on a plane, or simply a map or layout of a job to be done. House plans and farm conservation plans are both pure types of plans. I would like to discuss community watershed plans in this context. They are basically representations on a map of a job to be done, accompanied by appropriate descriptions of physical land and water conditions, problems, needs, improvement measures, costs, benefits, and often recommendations for carrying out the plan.

Current National Program Planning

Before we consider the particular attributes of watershed plans, however, let us digress a moment to review the status of current planning activities in our major national land and water resource programs. Land and water planning have followed two basically different patterns. Land, traditionally, has been considered static—fixed in time and place, fully responsive to individual initiative, and therefore subject to laws governing man's relations with his fellow man. Hence, land programs have most commonly been planned and administered within the framework of political or legal boundaries—states, counties, districts or ownership units.

Water, on the other hand, has been recognized as dynamic and transitory. Beyond certain narrow limits it is not subject to individual appropriation or control. It conforms only with nature's boundaries — watershed lines, underground aquifers, seacoasts. Hence water programs have tended to develop along river basin and watershed lines, notwithstanding many political efforts to the contrary.

In our major national action programs the most detailed and advanced planning at present is represented (1) in land programs by the conservation farm plan based on the concept of using every acre within its capability and treating every acre according to its needs and (2) in water programs by multiple purpose river basin plans such as those in the Tennessee Valley, Missouri and Columbia basins, and Central Valley of California.

Correlation of Land and Water Planning

During the past several years public recognition of the intimate relationship of land and water has increased rapidly. Technically trained men have always understood, of course, that use and treatment of watershed lands could substantially modify runoff characteristics, sediment loads, groundwater supply and other hydrologic factors. These in turn could modify both planning requirements and design of major downstream works for river regulation. Conversely, downstream river works for flood control, irrigation and drainage can materially increase the net acreage and yield of agricultural land.

Despite this general agreement in principle on the relation of land and water, there is, in fact, a wide gap in correlating planning for their development, use and conservation. For example, our most detailed land planning, that on individual farm and ranch ownership units, is being done generally, and payments are being made for recommended practices, without regard to factors outside the ownership boundary—unless of course those factors, mainly irrigation water supply or major drainage, are so dominant that improvements cannot be made on the farm without taking them into consideration.

Similarly, major river regulation works are being planned and built without regard to incidental changes in runoff or sediment production that are even now taking place as a result of going land programs being carried out by reason of their on-site benefits. Even greater beneficial changes could, of course, be expected from accelerated watershed programs.

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Features of a Watershed Plan

The watershed plan, in the opinion of those who have studied it most closely, is the tool needed to close the gap between conservation farm plans on the one hand and basin plans for management of large rivers on the other hand. The watershed plan is basically a water management plan. Although varying in scope, content and degree of detail to fit an infinite variety of local conditions, it could be described as having the following salient features:

1. A map (Figure 1) showing the water management measures needed in the intermediate zone between those required (1) primarily for on-the-farm purposes, which can be installed by landowners and operators with some technical assistance and financial aid, and (2) major river regulation measures which require complex engineering planning and are designed to produce far-reaching benefits such as irrigation of desert lands, power, navigation and flood protection for large urban areas. A watershed plan, thus, would not show individual terrace systems, farm pond locations, or land treatment measures of the type ordinarily shown on farm conservation plans. Nor would it show, because it would not cover such areas, main stem channel improvements such as impounding reservoirs, levees, river channel improvements, main irrigation distribution canals or similar features shown on river basin plans. It would show, however, for areas larger than individual farms, all of the water management and sediment control measures needed and economically justified between terrace outlets or farm boundaries on the one hand and major river channels on the other hand. This would include such measures as : (a) major gully stabilization by structures and vegetative plantings, (b) diversion ditches and dikes to collect damaging runoff into controlled channels, (c) small floodwater-retarding structures where local flood protection is needed, and including storage within these structures or in separate structures, where justified, for irrigation of small local areas, domestic and small community water suplies, and recreation, (d) stream bank and grade stabilization where needed on branches, creeks and tributaries of major rivers, (e) interfarm drainage canals tributary to major outlets, (f) floodways to take excess flow across wide flood plains to main river channels, (g) erosion control and water management measures along highways, railroads, pipelines and other nonfarm developments, and (h) desilting and debris basins to control sediment movement until erosion can be controlled effectively at its source.

2. The plan would include a map showing physical land conditions based on the techniques of soil conservation surveys and the land capability classification to serve as a guide to the planning of land use adjustments and application of treatment measures on individual farms and ranches.

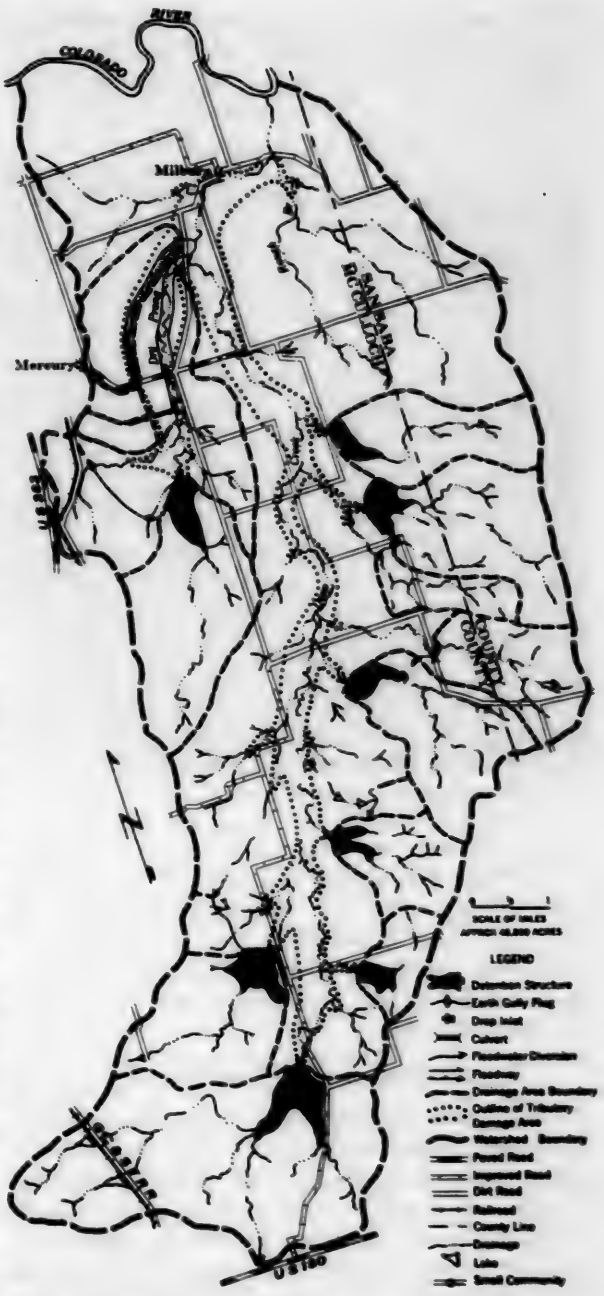

Figure 1. Floodwater-retarding structures and other water-management measures planned for the Deep Creek watershed, a tributary of the Colorado River of Texas.

3. The maps would be accompanied by a report which would describe the pertinent physical features of the area, the land and water problems, the opportunities

for their correction, the increases that could be expected in agricultural production as well as other benefits that would accrue by regulation of runoff, better distribution of available water for beneficial uses, disposal of excess water, and control of erosion required beyond that incident to application of needed farmland conservation practices. It would describe the principal physical characteristics of the various water management and sediment control measures such as size, capacity, and kinds of materials to be used; the costs of these measures and the relation of total costs to total benefits of the plan. The report should also describe the effects that such a water management plan together with land conservation measures might be expected to have downstream on major river developments. Moreover, it should set forth criteria for planning the use and treatment of land on individual farms and ranches in such a way as to secure the maximum off-site benefits in water management and sediment control consistent with on-site economic and social considerations. The report might also describe available ways and means for carrying out the plan, including kinds of Federal, State and local resources available and any needed legislation, regulations, appropriations, taxation, and cooperative agreements. It should describe provisions required for operation and maintenance of improvements following their installation.

It is not practicable from the standpoint of time, cost, or the extent of local interest to prepare such plans at one time for complete river basins or large watershed areas. Watershed planning is rather a tool to aid local people in cooperation with agencies of government to provide for water management plus a framework for sound farm conservation planning on areas in the general size range from a few square miles up to several hundred square miles.

The Community Watershed Concept

Another, and even more vital consideration dictates the selection of small watersheds as planning units. Major river basin improvements touch directly on the lives and interests of only a small proportion of the basin residents. Although most people living in a river basin may indirectly receive some resulting service such as power, the average individual probably does not feel an intimate relationship to the works of improvement, because he had no direct part in their acomplishment, nor did their installation touch his personal life and private affairs. On the contrary, small watershed plans involve cooperation and major responsibility on the part of almost every landowner and operator within the area. This distinction was recognized by the President's Water Resources Policy Commission which introduced the useful concept of the "community watershed." (1) They pointed out that "*one of the most decisive factors in the success or failure of watershed development work . . . is the cooperation of the people living in a watershed. . . . Unless they understand the need for watershed development, and regard themselves as a functioning part of the watershed, little of lasting value is likely to be accomplished.*"

"*A watershed so large that its inhabitants cannot see their relation to it, or feel responsible for it, is too large to serve as a conservation unit. On the other hand, one so small that even major improvements would benefit only a small group could not command the active support and participation of the surrounding community.*"

"*The practical-sized watershed is one on which the residents are willing to spend time, money, and energy because they regard it as their own. It is an area with which they associate their pasts, and particularly their personal futures. It provides a wide range of improvement opportunities, with a correspondingly wide range of potential benefits, both public and private. It has sufficient population, with a diversity of interests, to assure effective support for the full range of improvement work.*"

Major responsibility not only for carrying out a watershed plan, but for aiding in its development rests with farm group and urban community leaders, soil conservation districts, and other agencies and instrumentalities of the states.

River Basin Program Development

Community watershed planning, and action based on such planning, does not, however, preclude the formulation of comprehensive programs along river basin lines for conservation and management of land, forests, grass, wildlife, and what has been called "little waters." On the contrary, certain kinds of determinations need to be made in river basin areas to provide a sound basis for community watershed planning. For example, reasonable determinations should be made of the aggregate effect on main stream flow and the need for its regulation as a result of water management in all community watersheds tributary thereto. The potential effects of watershed treatment on silting of main stem reservoirs should be determined. Reasonable answers to these and similar questions can be obtained through well known sampling procedures involving watershed planning on only a small proportion of the total river basin area.

Moreover, the general nature and scope, as well as the potential cost of water management up to the farm boundary, should be determined by river basins. Ultimately, public investment in this aspect of water management may equal or exceed public investment in water management on main stem rivers. Even though man-

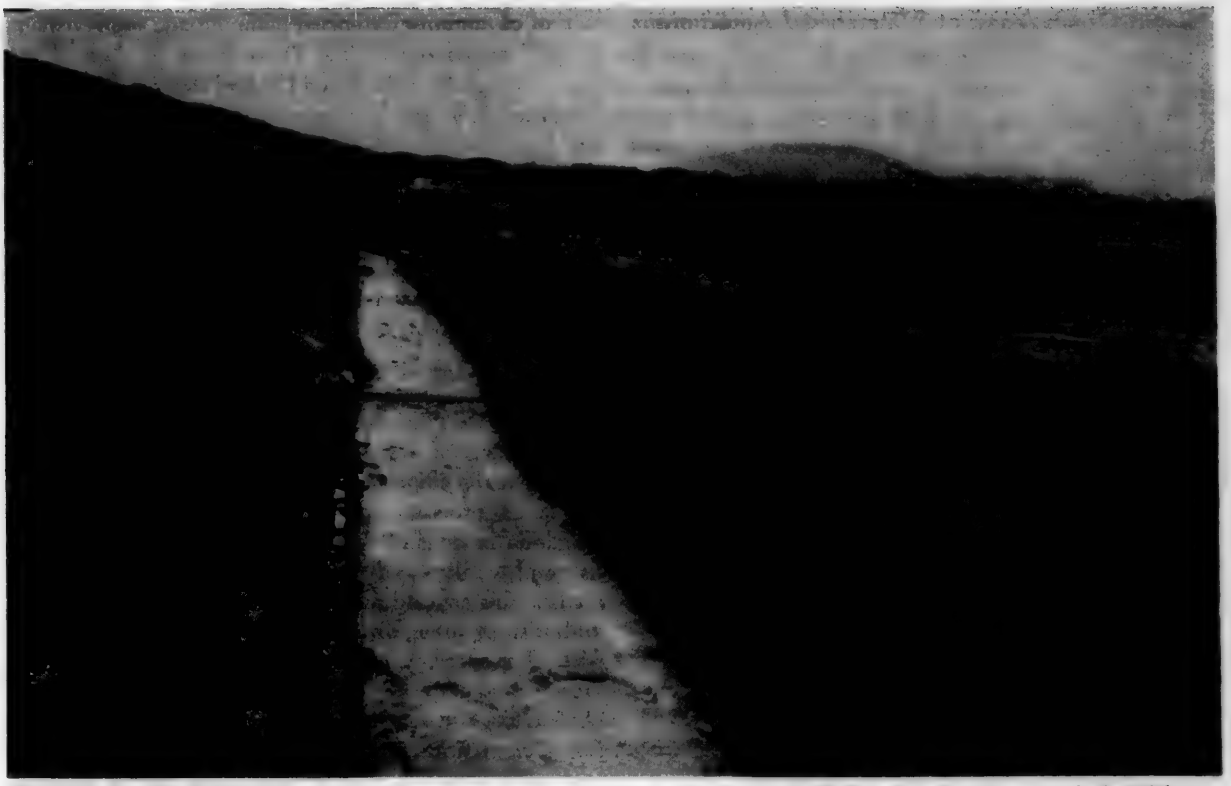

Figure 2. Stabilized waterway protected by pipe and wire revetment, San Fernando Valley, Los Angeles watershed, California.

agement of little waters is at least twenty years behind the regulation of major streams, the aggregate values affected by or inherent in little waters may equal or exceed that of major rivers. For example, river basin and watershed surveys have indicated that as much as 75 per cent of all flood damages may occur upstream from main stem flood plains. Remaining potentialities for enhancement of agricultural production by flood control, irrigation and drainage may be greater on the large aggregate acreage along small streams than on large streams. It is therefore proper and necessary that water management program formulation should be carried out along river basin lines. But community watershed planning and small watershed management in more critical areas cannot wait until river basin program development is completed.

Land Programs on a National and State Basis

On the other hand, even though the solution of land and water problems is conceded to be intimately related, many conservationists doubt the wisdom of associating land use and treatment programs primarily with river basins. The arguments in favor of this view include (1) the fact that the on-site benefits of land use and management practices far exceed the off-site benefits in nearly all agricultural areas. Food and fibre production requirements limit the types and intensity of application of land management practices that might be desirable primarily for their off-site benefits, (2) the rate of installation and the assurance of maintenance of land management measures are subject to changing social and economic factors and changing land ownership. These constantly changing factors require continuing revisions in national programs of education, technical assistance, financial aids, credit, price support, marketing agreements, grazing regulations and forest management. These going national agricultural programs are administered along state and other political lines through long established channels of cooperation with state and local agencies, (3) ample authority already exists in federal and state law for carrying out all aspects of land use and treatment measures needed for either on-site or off-site purposes; but appropriations are inadequate for desirable acceleration, intensification and adaptation of land conservation programs needed to keep pace with water management programs if the latter are ever carried out on a scale commensurate with major river basin developments.

Rapid Organization of Watershed Associations

Evidence is rapidly accumulating that local people in many sections of the country have become acutely aware of the missing link in our land and water resource programs. In less than five years several scores of watershed associations and other organized local groups have come into being for the avowed purpose of achieving objectives which they feel are not being met through going national programs. Such associations have been widely organized in the states of Arkansas, Illinois, Iowa, Kansas, Louisiana, Michigan, Nebraska, Oklahoma, Pennsylvania, Texas, and Wisconsin. The American Watershed Council has been founded to further their objectives. The motivating force in these associations has been flood control here, water supply there, drainage in another place, pollution abatement on some streams. In all cases these associations are supporting general land management and conservation objectives, but their very existence and rapid multiplication show that there is a missing link in going national programs. Although the Federal Government even in this year of international crisis is pouring more than a third of a billion dollars into land conservation and forestry programs and more than two-thirds of a billion dollars into reclamation, rivers and harbors, and major flood control works, needs recognized by local people are not being met.

Operations Under the Flood Control Authority

The only Federal program aimed in the general direction of community watershed planning and improvement is that carried out by the Department of Agriculture under authority of the Flood Control Act of 1936. Total funds available for this program in the fiscal year 1952 are approximately $7,000,000. Nevertheless, operations being carried out under this authority in only 11 watersheds, based on subwatershed planning, have already demonstrated that the community watershed approach is sound. The accomplishments to date in these areas have in no small measure influenced the rapid growth of watershed associations.

The Flood Control authority, on the other hand, is obviously inadequate to accomplish the stated objectives of many watershed associations. For one thing, it limits consideration of watershed objectives to flood control. Other equally important objectives such as drainage of wet lands, provision for supplemental water supply for irrigation or domestic and municipal uses, protection of fish and wildlife and pollution abatement are not covered by this act and must be considered, if at all, under authority of other diverse and often conflicting legislation. The wording of the Flood Control Act, namely, "runoff and waterflow retardation and soil erosion prevention on watersheds," overlaps authorization in the Soil Conservation acts on the one hand and leaves an undefined boundary on the other hand with authorization of "investigation and improvements of rivers and other waterways for flood control and allied purposes." This has led to delaying and frustrating administrative

Figure 3. Floodwater retarding structure and gully stabilizing structures, Sandstone Creek, Washita River watershed, Oklahoma.

and jurisdictional differences of opinion between Federal agencies, between the executive and legislative branches and between legislative and appropriation committees in the Congress. As a result of the imperfections in this Act, the Department of Agriculture over a period of 15 years has succeeded in obtaining authorizations for works of improvement in only 11 watersheds constituting 1½ per cent of the total land area of the United States.

The Soil Conservation Service, in addition to its work under the Flood Control Authority, has been aiding a number of these organized local groups by providing watershed planning assistance through soil conservation districts. But available resources, even for planning, are extremely limited and no source of Federal or state aid is generally available to help local people install water management measures on their community watersheds.

Guideposts for Future Actions

Although it is impracticable to detail here a more adequate alternative method for supplying the missing link in river basin development, use and conservation, it does seem appropriate to list a few guideposts for consideration of those groups which are already seeking a simple and adequate way to close the gap between conservation on the land and improvements on the major rivers:

1. Community watershed improvement, like conservation on individual farms, should be primarily a local responsibility.
2. Technical assistance in community watershed planning should be available from a properly staffed Federal agency upon specific request by responsible organized local groups or state agencies, which can give evidence of intent and ability to assume primary responsibility for carrying out and maintaining the plan.
3. River basin program development should be a joint undertaking of the Federal government and the states. It should consist primarily of water management programming, leaving agricultural land management within the framework of existing national and state programs except for developing information on modifications that are desirable to achieve maximum off-site benefits without diminishing on-site values.
4. The Federal and state governments should carry out an aggressive campaign of informing local people about land and water management needs, benefits and methods for achieving adequate watershed protection.
5. New Federal legislation should be enacted to provide
   (a) a channel through which organized local groups and state and local agencies can petition for Federal assistance in community watershed planning to embrace all legitimate land and water objectives in the zone between individual farms and major river basin improvements.
   (b) designation of agency responsibility for such planning and for providing engineering service and technical assistance to local groups in carrying out such plans.
   (c) designation of agency responsibility for assisting local people through direct contracting, grants, and/or loans in installation of water management measures in community watersheds.
   (d) provision of Federal aid beyond the planning stage only upon determination that the total benefits to whomsoever they may accrue exceed the total costs.
   (e) adequate provision and safeguards for maintenance and protection of the Government against future liability.
   (f) authorization of appropriations necessary to provide effective help to local groups, based on the principle of equitable proportions of Federal assistance being made available for (1) conservation on individual farms and ranches, (2) community watershed water management programs, and (3) major river basin works of improvement.
6. Laws and regulations governing the administration of national land programs should be amended, as necessary, to require that in community watersheds where organized local groups, or state and local agencies are carrying out approved watershed plans, all services and aids will be directed toward accomplishment of the plan insofar as it is not inconsistent with national program objectives.
7. Community watershed plans, involving a large number of individually small improvements, should not be placed in the same category as public works requiring individual Federal authorization. As community watershed improvements should be primarily a local responsibility, Federal aid could perhaps best be extended under a nation-wide authorization, subject to adequate safeguards, as assistance in conservation work is now extended to individual landowners. These safeguards should provide for review of plans by local interests and Federal agencies concerned with major river works of improvement below the community watersheds.

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Putting the Watershed Plan to Work

W. L. HEARD

IN THE LITTLE TALLAHATCHIE and Yazoo River a program of runoff and waterflow retardation and soil erosion prevention authorized for prosecution by the Department of Agriculture in the interest of flood control has been under way for about five years. In the same area a flood control project of the Corps of Engineers has been under way for over 15 years. During the period in which the Department of Agriculture has been engaged in putting its part of the authorized Flood Control Plan to work, sound principles of watershed operations have been demonstrated over and over.

These two watersheds, which are geographically one, lie in the northwestern part of Mississippi. They take the shape of a large pear, with the large part near the Tennessee-Mississippi line, and the stem end pointing southwest, emptying into the Tallahatchie—Yazoo River which passes along the foot of the bluffs in the Delta section of the state. There is an unusual amount of good valley land in these watersheds, and there are numerous watershed problems affecting these valley lands.

Putting the Plan to Work

Other papers in this panel have covered the technical requirements of a watershed plan for a soil and water conservation program. My paper covers the final phase —that of putting the plan to work. This in itself assumes the existence of a coordinated operations plan before the work is undertaken. I should like to emphasize a few points in this regard:

1. The full cooperation of all Federal, State and local agencies in carrying out their accepted responsibilities in a watershed program is most important. Frequent consultation is imperative in regard to revision of plans, priority of work, the financing of activities and carrying out of cooperative endeavor if a successful watershed program is to be carried out.

2. The coordination of operations may be as important as the technical plan. In such coordination, the various works of improvement must be planned, timed and applied in their proper sequence.

3. The watershed operation will vary to fit the objectives of the watershed plan.

4. The operations program is dependent on the framework of laws — local, State or Federal — under which the operations must be carried out, or on the likelihood of changes which will permit the necessary action.

5. Efficient operations require thorough understanding and acceptance by local groups or individuals who are to assume the leadership in carrying out the program, as to the watershed objectives and how the actions of each group or individual will contribute to attaining these objectives.

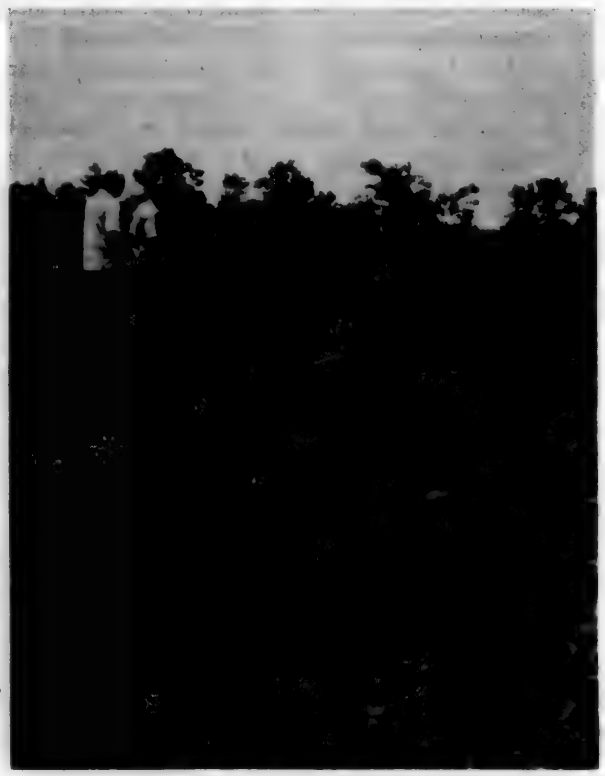
6. Local leadership must be put to work if the watershed program is to move along in its proper sequence and volume.

7. Concerted action by many is the essence of most watershed activities for soil and water conservation, whether the watershed be a small individual watershed of a half dozen farms, or a major watershed composed of thousands of farms.

8. Organizational procedures of agencies or groups must be revised to permit effective participation in watershed activities.

The first step in our operations program in the Tallahatchie-Yazoo watersheds was a restatement of the ob-

Figure 1. Kudzu planted on eroded 20-acre idle land area in spring of 1949. The sand and silt from this area empties directly into the Tallahatchie River Valley. Part of the sand was deposited on a 5-acre valley field of Class IIA immediately below this area resulting in its retirement from cultivation to permanent hay. Cost of establishment to kudzu was about $20 per acre. Near New Albany, Mississippi.



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jectives, based on an analysis of facts and conditions known to the technical staff assigned to flood control operations. It was determined that the broad objectives of the watershed program should be:

1. Sedimentation control by reduction of erosion.
2. Improvement of soil conditions to increase infiltration by vegetative and other means, to reduce runoff.
3. Reduction of peak flows and duration of overflows in the valley lands, by improvement of channels or by water-detention structures.

With these objectives in mind an outline operations plan was prepared which stated in broad terms the priority areas in which work should be undertaken, and set up a time schedule for accomplishment of various phases of the work. In determining these priorities it was found that conditions varied tremendously throughout the watershed, to the extent that subwatersheds, or even minor watersheds constituted areas with different priority of objectives, and therefore, presented completely different operations problems.

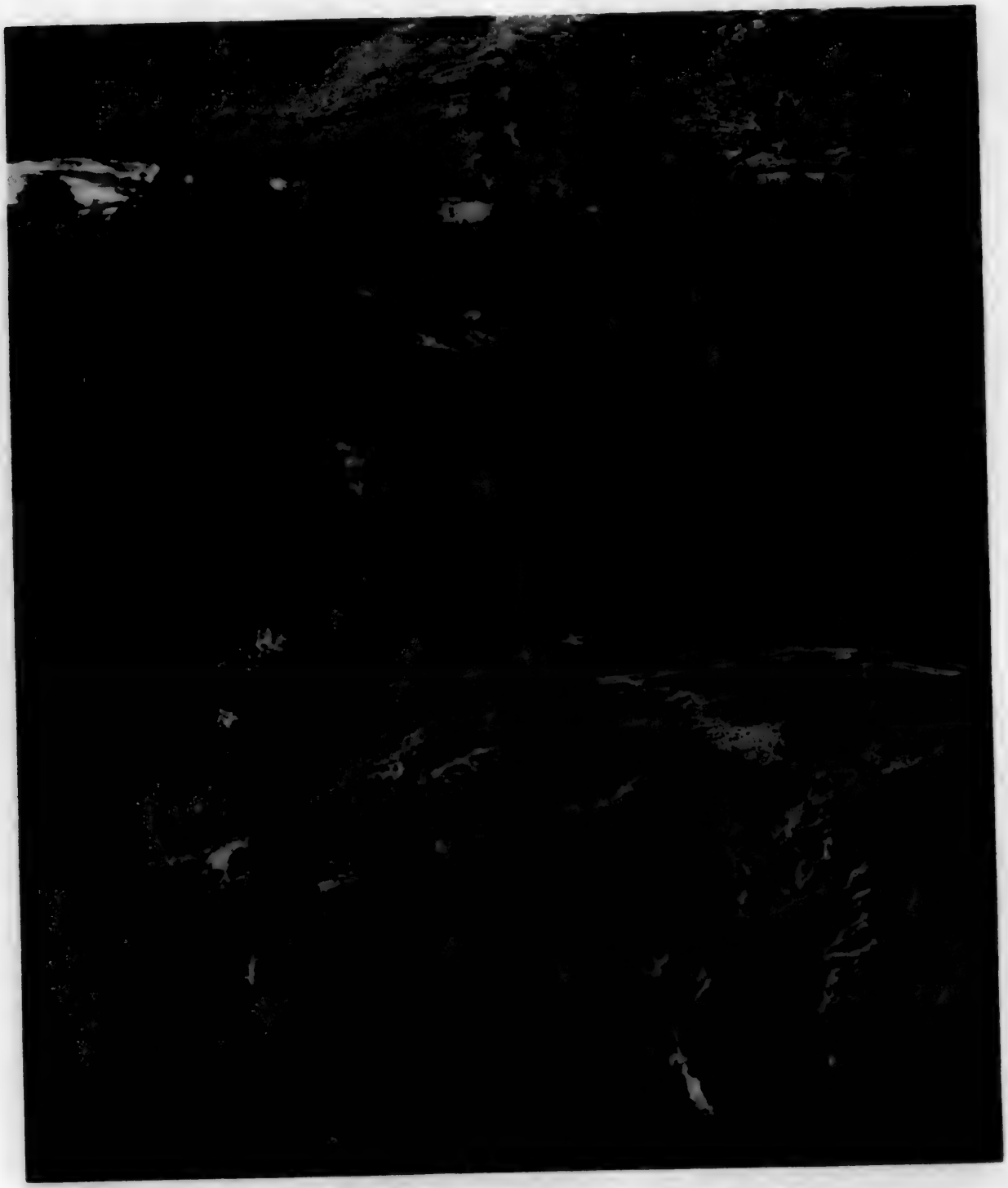
Subwatersheds are Divided into Minor Watersheds

This brings us to the third point outlined above, that of varying the operations plan to fit the objectives as determined by an inventory of the conditions in each watershed. The subwatersheds were subdivided into minor watersheds which are complete hydrologic units or problems. For each of these an operations plan was prepared consisting of a proposed land use plan, a proposed water-use plan, and a statement of operating procedure for getting the job done. The land-use plan was made by the technician on the ground, using land capability maps as a basis for needed land-use recommendations. The water use plan was prepared in essentially the same way, using reconnaissance surveys as a basis for determining needs. The operations plan was determined by the technician in consultation with Soil Conservation District Commissioners, County Boards of Supervisors, representatives of U. S. Forest Service, PMA, Extension Service and farmers. Thus it can be readily seen that operations planning and the actual jobs to be done will vary considerably, even between small watersheds.

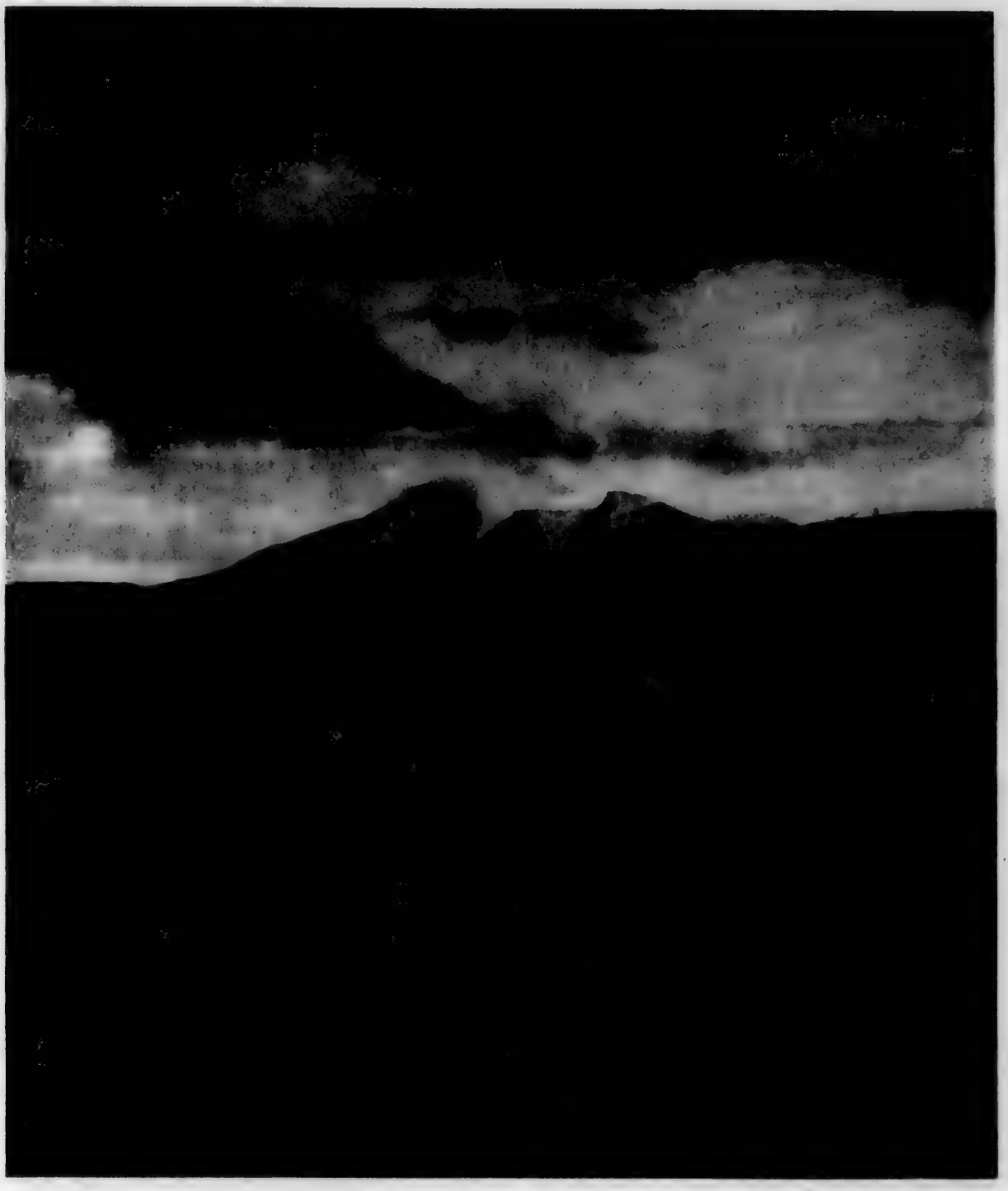
The Soil Conservation Service and the Forest Service found early in the program that their ability to get the job done was definitely tied in with the existing framework of laws. This applied first of all to interpretation of Federal laws under which we were operating, particularly with regard to the restrictions which they placed around our operations. We found that additional Federal legislation was necessary to clear up some points. Many matters regarding cooperation between Federal and State agencies have had to be cleared up, frequently by reference of matters to the Solicitor for the Department or to the Attorney General of the state. All of these matters require careful determination and very definitely limit the course of action which can be taken.

The matter of local financing is most important,

Figure 2. Sediment detention basin below badly gullied uplands and immediately above bottom lands which have been severely sanded on West Goose Creek, near Oxford, Mississippi.



An aerial view of a badly gullied area planted to trees in 1949-1950 near New Albany, Mississippi, to control the excessive runoff of silt and sand.



This view of an irrigated mountain meadow on the Upper Gunnison River in Colorado. Some of these areas are estimated to occupy from 500,000 to 750,000 acres.

Figure 3. Former Crop Land, Class III E and IV E, seeded to sericea and crimson clover in 1950. This 15-acre field in the Tallahatchie River watershed now gives almost complete protection against erosion and clearly reduces the rate of run off. New Albany, Mississippi.

whether it be the financing of a bond issue for cooperative clean-out or excavation of a channel, the cooperative financing of fire detection and suppression by Federal agency, State or county, or the financing of the planting of a 20-acre field of kudzu or pine tree seedlings by an individual farmer. Each problem has its bearing on the progress in carrying out a watershed program. The failure to recognize, evaluate, and lay out a definite course of action may result in an unhappy ending insofar as solution of a particular objective is concerned. An untreated group of critical gullies or roadside ditches may be just the source of the sedimentation problem on Farmer Jones' place two miles downstream.

In the watershed programs now being formulated in the survey or pre-authorization stage by the Department of Agriculture, agreement is being reached between the various Federal agencies and State agencies with regard to what the program shall consist of, and generally, how it shall be carried out. This was undoubtedly done also in the case of the authorized watersheds, but it certainly has not eliminated the necessity of the full cooperation of all agencies at subsequent stages in carrying out of the accepted responsibilities of each agency. In many cases we have found it necessary to obtain new agreements as to responsibilities among the Corps of Engineers, the Soil Conservation Service, the U. S. Forest Service, and in most counties, the Production and Marketing Administration, Extension Service, Vocational teachers, Highway Department, County Boards of Supervisors and others.

Particularly notable is the working arrangement of the Soil Conservation Service with the Corps of Engineers and U. S. Forest Service, these being among the principal contributors to the activities in the Little Tallahatchie-Yazoo River Watershed. Representatives of these groups meet frequently and work out their joint operations problems most effectively.

After we developed the skeleton work plan, we set about to acquaint the leadership within the watershed concerning the proposed activities. This leadership included Boards of Commissioners of Soil Conservation Districts, County Boards of Supervisors, all civic clubs, Farm Bureau groups, County and State Agricultural Coordinating Councils, Boards of Commissioners of Drainage Districts, bankers, professional men, and others. The objectives of the work were clearly presented, the local problems pointed out and need for local or other action stressed.

Working through the State Agricultural Coordinating Council, a coordinated informational and educational program was developed and put into effect in order to obtain general understanding by all agricultural workers involved, and to get all interested agencies to carry to the farmers of their work area in priority minor watersheds a coordinated effort in informational and educational work pertaining to watershed activities. In short, we are taking advantage of every opportunity offered to improve the general understanding of the problems involved and appreciation for the work being performed. Moreover, we have placed in local hands wherever possible the leadership responsibility for carrying out various phases of the work. All work on private lands is carried on through the Soil Conservation Districts in the watershed. District Commissioners are encouraged to fully accept their responsibility in this

work as a part of the program of work for their respective districts. The State Association of Soil Conservation Districts has recognized its responsibility, and has established a standing Flood Control Committee to represent the State Association in watershed activities throughout the state.

Many examples of the effectiveness of local leadership in watershed operations could be cited, but it is sufficient to say that without such leadership, even in small groups, the job would be infinitely more difficult if not impossible to perform. It has been our aim to get as many people working on the problem as possible. There are over 30,000 farms in the watersheds. Our present objective is to obtain about 1500 new district cooperators each year in order to complete the program on schedule. Careful control is maintained to see that these 1500 new cooperators are developed in the area where the emphasis is to be placed, whether it be a small watershed affecting a few farms, or whether it be an area affecting 100 farms. The educational work is stressed with small neighbor or watershed groups in accordance with the predetermined priority. In order for the work to become effective in a relatively short time, it is important then that concerted action of individuals, groups, or enterprises be accomplished within the period planned.

Many local organizational changes have been necessary in both the Soil Conservation Service and Forest in order to handle the increased work load. Careful and continuing analysis of the technical and other personnel requirements is essential to effectively plan, lay out and supervise a watershed program. The need for engineering, forestry or other specialists is accentuated, since the objectives and treatment are more specific and more complex than for scattered random farms.

Many new operational procedures have had to be worked out to fit new practices or requirements. For instance, the planting of several million kudzu or pine seedlings each year on critically eroding land is being done by contract. Local farmers who have a seasonal surplus of labor or equipment are contracting to perform the work at a unit price per thousand plants. Another example is the production by local farmers of kudzu seedlings for use in watershed plantings.

The problems which arise are without end, never lacking in novelty or interest, and presenting a continuing challenge to technicians and administrators. It is my belief that the watershed approach to operations in order to solve many of our larger soil and water conservation problems is fundamental. It enables us to relate cause and effect, and to solve our pressing problems on the basis of sound principles. It is my hope that it will be utilized to a much greater extent in the years ahead.

The Economics of Idle Resources

L. GREGORY HINES

National policy goals emphasizing full utilization of resources to achieve full employment and maximum output have overlooked the critical difference between human and natural resources. In the case of human resources, continuous employment is essential to achieve maximum output; in the case of renewable natural resources, periods of enforced idleness may be required to maintain long-run maximum output by the American economy. In addition, by accepting commercial profitability as the sole criterion of the economic worth of resources, socially desirable uses of idle resources are frequently overlooked. Some resources attain their greatest economic and social worth when commercial exploitation is prohibited.

"PROGRESS SEEMS TO MEAN, all too often, the projection of slums into the wilderness."[1] This observation of Roderick Haig-Brown highlights one of the intellectual blind spots of the post-depression era. America's experience during the 1930's brought more than breadlines and public works projects; it stimulated a prolonged re-examination of many of our social values and institutions. The condition of our natural resources and the methods used in their exploitation received belated attention during this period. Because of the obvious physical deterioration of our soil resources during the depression—dramatized by the coincidence of low prices for the farmer's products and winds that swept away his soil—conservation became an announced goal of national policy, although in practice it was frequently combined with and diluted by other objectives.

But while the depression seared men's minds with the fear of a recurrence of unemployment and idleness, it strengthened a dominant American belief that the only "good" resource was a resource in use—commercial use.

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"Full employment," its attainment and perpetuation, became the overriding goal of national policy, and during the confusion following World War II we "guaranteed" its survival by the passage of legislation which expressed more of a hope than a method of achievement. Subsequent developments allayed our fear of unemployment and depression, but did not diminish our enthusiasm for full utilization of our resources. Increased national output was substituted as the overall goal of national policy, initially to help check price inflation and later to speed the defense mobilization program.

It is natural, if illogical, for the benefits from full employment of human resources to be extended uncritically to full employment of *all* resources. Progress, as reflected by increasing per capita real income, has generally been achieved through the exploitation of a larger portion of our resource base. Again, the natural inference is that the more resources we bring under commercial exploitation, the greater will be our national output and the higher our standard of living. But this convenient capsule theory of resource utilization ignores a fundamental difference between human and natural resources: human resources deteriorate with idleness; natural resources may require periods of disuse for replenishment.

The unemployed worker is subject to all the corrosive influences of inactivity: impairment of skill through inability to practice his craft, deterioration of morale from inadequacy of income and uncertainty of future employment, and—at the social level—loss of national output that can never be recovered. A man-hour of unemployment is an irretrievable loss to society. When multiplied by millions, as it is during a depression, it becomes an irreparable loss. But a strict identity between waste and disuse does not extend to natural resources.

Our exhaustible resources — coal, iron ore, bauxite, and the like—are preserved for future use by abstinence from current consumption. Renewable resources—soil, water, timber—are not only conserved during periods of commercial quiescence, but under proper management may undergo extensive and necessary rejuvenation. It is at this point that full utilization of manpower resources differs significantly from full utilization of natural resources. In the case of manpower, a sustained high level of output can be achieved only by the continuous employment of all human resources that are available in the labor market. In the case of natural resources, sustained capacity output can be maintained only if renewable resources are not depleted without regard to their recuperative ability.

Intensive and continuous use of such basic resources as soil, water, and timber is likely to destroy the resiliency of the resource and diminish the productivity of the resource base. This does not mean that whenever the rate of resource depletion exceeds the rate of resource replenishment that man is courting disaster. We would allow ourselves to be conquered by a sentimental fallacy if we sought to return our resource base to its primitive luxuriance. Renewable resources can be depleted without immediate economic and cultural impoverishment, but we should recognize that the rate of resource depletion cannot persistently exceed the rate of resource renewal without weakening the carrying capacity of the resource base.

This elemental consideration needs re-emphasis during a time when the goals for increased national output stress capacity production by both natural and human resources. In our release from anxiety over the ability of our economic system to provide employment for all those seeking jobs after World War II, we should not ignore a less apparent but important danger to our resource base. *Full employment may bring with it "full destruction" of some of our renewable resources unless they are afforded the idleness necessary to sustain their productive capacity. In turn, unless the rate of depletion and the terminal date of exhaustible resources are clearly recognized, future output will suffer as a result of over ambitious current production goals.*

Although the American system of land use rests predominantly on private initiative, the practices of individual resource owners exert influences that affect the productivity of resources owned by others as well as the aggregate national output. For this reason, the attainment of maximum output must consider the influence of the system of resource use as well as the effect upon resource utilization of the goals of national policy. For example, the cultivation of submarginal land and the use of improper methods of cultivation raise problems at two levels: (1) a *private* problem for the farmer tilling submarginal land and/or employing undesirable methods of cultivation who receives an insufficient return for his efforts and suffers deterioration of his land and a decline in the value of his investment, and (2) a *social* problem that occurs when such private practices result in soil deterioration extending beyond the holdings of the individual whose practices have encouraged wind and water erosion and leaching. Thus, the removal of native grasses and timber in order to cultivate land of low fertility or land in an area of normally insufficient rainfall may result in more than the impoverishment of the offending farmer: it may cause adjacent areas of high fertility land to be covered alternately with layers of productivity-robbing silt and dust.

The social loss from the impairment of the high fertility land in such cases will generally exceed the temporary addition to our national output from the cultiva-

tion of submarginal land. For this reason, withdrawal of inferior land from exploitation, as well as improvement in the methods of cultivation, is essential to *continuous* capacity output. The Twentieth Century Fund has estimated that an expenditure of from six to nine billion dollars (in terms of 1947 prices) spread over a period of fifteen years would be required to rehabilitate our land to the point where the population-resource relationship is in reasonable balance. (2) This estimate does *not* include the cost of withdrawing unproductive land from cultivation, or the expenditures that would be required to rehabilitate non-agricultural natural resources.

A program designed to eliminate the cultivation of submarginal land would add more than 780 million dollars to the above figure, remove about eighty million acres of land from farming, and take twenty years to resettle approximately half a million farm families. The point to remember is that emphasis upon a crude concept of full employment may cause us to ignore the seemingly paradoxical fact that the optimum use of some resources is permanent disuse; and for others, periodic disuse. That is, idleness represents the only economic use of those natural resources that are incapable of replenishing their productivity.

The economic desirability of enforced idleness for some of our natural resources is not confined to land areas that require uniquely favorable market conditions and abnormally heavy rainfall for profitable cultivation. The standard of commercial profitability breaks down in other cases when broad social considerations are involved. By relying on purely commercial standards a wide variety of resources which from the social standpoint should remain idle are brought under commercial exploitation. For example, the important social worth of wilderness areas is frequently discounted in favor of trivial private gain. Standing timber may be more useful to society as a protection against rapid runoff in a watershed region than as harvested board feet for the construction of homes or the production of pulp paper. In the case of exhaustible resources, mining of commercially workable mineral deposits may be accompanied by the destruction of other and socially more important resources in order to provide a modicum of private gain.

In such cases we need to distinguish clearly between the private gain and the public loss, and to enforce strict protection of the public's interest in idle resources. Unfortunately we cannot turn to the government in full confidence that all private spoilation will be prevented. Indeed, the government itself is frequently more than a passive partner in the misuse of natural resources. The emergence of big government beholden to pressure groups in some natural resource matters has permitted special (and minor) interests to subvert the general welfare. In addition, jurisdictional disputes among various governmental agencies over the administration of natural resource projects and competition for Congressional appropriations have frequently obscured the broader social interest by petty considerations and conflicts. Competition among business units is productive of much public good; but competition among governmental agencies seems to bring just the opposite: larger bureaucracy, looser public purse strings, and increased vulnerability to pressure-group politics.

Probably no better illustration of the enduring public interest in idle resources and the conflict with private exploitation and some forms of government intervention is found than in the case of the wilderness area. The wilderness area—a remnant of primitive America—is rapidly vanishing from our continent largely as a result of a latter-day extension of the frontier philosophy, which encouraged the exploitation of all resources in the mistaken belief that progress was made in proportion to the area of land cleared and the number of trees cut. We may eventually realize that wilderness areas constitute one of our unique and highly perishable social assets, an extreme illustration of the case where certain resources attain their greatest social value when subjected to enforced commercial idleness. The worth of such areas as barriers to erosion is fairly well known; their more positive uses as wildlife sanctuaries, scientific laboratories where "nature's balance" is relatively undisturbed, and as unusual recreational regions are less fully appreciated. These uses are not susceptible to the money calculus of the market place, but become more important with every extension of urbanization and industrialization.

A necessary first step toward achieving *sustained* maximum output for our economy is the abandonment of a superficial version of full employment and maximum output goals. The critical importance of conserving resources in order to continue using them must be included as an essential part of our national policy. This objective must embrace and appreciate the special economic characteristics if the gradual destruction of our resource base is to be prevented. It must be clearly recognized that private gain is not always synonymous with public welfare, and that commercial use of natural resources may sometimes destroy both the resources and more important social values. *In short, recognition of the real worth of idle resources is a neglected cornerstone of an effective conservation program.*

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Water in the Southeast

JOHN J. NOLL

The Southeast is blessed with an abundant supply of good quality water. In fact, the water supply of this section is one of its most important natural resources, and one that is constantly being renewed. With water shortages occurring in many places elsewhere, the huge supplies of the Southeast are still largely undeveloped. Rainfall, the source of all our water, is usually more than adequate and well distributed throughout the year.

WATER IS A PRIMARY FACTOR in the rapidly expanding industrial growth of the South. An important reason for selection of the site near Aiken, South Carolina, for the new billion-dollar hydrogen bomb plant was the assurance of adequate supplies of high chemical quality water.

That the people of this section are well aware of the importance of water is illustrated by the Santee-Cooper River development at Charleston, South Carolina, where an entirely new fresh water source with a potential of 10 billion gallons daily is being developed.

More and more we are coming to realize what a tremendous asset our streams, rivers, and ground water supplies represent and the extent to which they influence our economic future. With a constantly increasing water demand, the critical water shortages and serious pollution problems occurring in some localities are cause for serious concern. It is time, therefore, for an inventory of our water resources, an examination and better understanding of our water problems, and careful consideration of future water needs.

Water—Definitions

Water is constantly in motion. This motion follows a definite pattern of events called the "hydrologic cycle" (1) (5) (8). Water following this cycle evaporates wherever it is exposed to the air; rises into the atmosphere; is finally condensed and falls as rain or snow.

We begin to measure our available water when it falls on the ground (precipitation records). Some of it runs off the land surface into streams, rivers, and lakes, and is called surface water. Some percolates down through the soil below the reach of plant roots to the water table, the zone where all openings and spaces in the rocks are fully saturated with water and in which the water flows by gravity. This is called ground water.

Ground water is continually in motion. This movement may begin at the recharge areas—areas which allow water from rainfall and surface sources to seep downward to replenish ground water stores. The flow is mainly by gravity laterally toward areas of natural or artificial discharge where it returns to the surface, but may be upward as well as downward.

Ground water may be under water-table or artesian conditions (5). Under water-table conditions, the top of the zone of saturation is at atmospheric pressure, and the ground water behaves much like water in a surface reservoir. The zone of saturation extends downward until impermeable rocks are encountered. Wells which penetrate water stored under water-table conditions drain water from the pores and spaces between the rocks.

Under artesian conditions, water becomes confined under pressure between two layers of impermeable material. Artesian aquifers are comparable to a piping system in that they are full of water, receiving water from the recharge area at the upper end and discharging it at the lower end (8). Artesian water will rise in a tightly cased well with a head equivalent to the difference in elevation between the well intake and the elevation of the water table in the recharge area, less the loss from friction. If the head happens to be above the ground surface, as often occurs in valleys and the lower Coastal Plain, the well will flow.

In the Coastal Plain, ground water very commonly occurs under both water table and artesian conditions in the same area.

Water Resources in the Southeast

Southeastern United States is an area of excessive precipitation. Average annual rainfall varies from a low of 32 inches in the upper Shenandoah Valley of Virginia to 84 inches in the Blue Ridge Mountains of North Carolina. The regional average rainfall is about 50 inches (Figure 1) (9).

Average annual runoff varies from 10 to 40 inches (Figure 2) (3). Seasonal differences in runoff are usually not pronounced. However, the streams above the Coastal Plain are flashy. In the limestone areas many of the smaller streams are perched above the permanent water table and are intermittent in character. The Blue Ridge area with high precipitation, high rates of runoff, and low turbidities is one of the best sources of high quality surface water in this section.

There are four principal ground water areas in the

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Southeast. These are the (1) Coastal Plain, (2) Piedmont Plateau, (3) Blue Ridge Mountains, and (4) Old Sedimentary Areas (Figure 3).

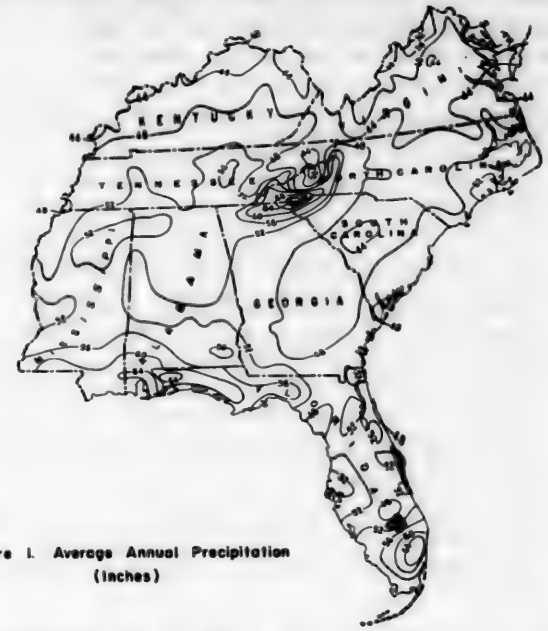

Figure 1. Average Annual Precipitation (Inches)

The Coastal Plain area is probably the most productive ground water area in the nation. It comprises 57 per cent of the Southeastern Region. The loose, unconsolidated nature of the Coastal Plain formations provides ideal conditions for large ground water storage and rapid recharge. With the exception of occasional areas of naturally brackish water, the water recovered from this area is generally low in dissolved materials and is of excellent chemical quality. Layers of impermeable clays and marls, alternating with permeable sands, gravels, and limestone, all dipping toward the coast, result in artesian conditions throughout most of this area (1).

Ground water conditions are poor in the Piedmont Plateau. The limited ground water supplies are usually sufficient only to meet the needs of smaller communities.

The Blue Ridge area has very limited ground water supplies. Numerous small springs furnish moderate amounts of water.

The area of Old Sedimentary formations west of the Blue Ridge is variable as to ground water conditions. Occasionally large supplies are available from sandstones and limestones. Large supplies are sometimes obtained from deep alluvial deposits.

Water Use and Problems

It is estimated that in 1950 about 14 billion gallons of water were used every day in the nine Southeastern states for municipal, industrial, and rural use and for irrigation. About 83 per cent of this water came from surface sources, and the remaining 17 per cent from ground water supplies. About 400 million acre-feet of surface water was used annually for hydroelectric power (4).

During the past 20 years the use of water has been growing by leaps and bounds. Largely responsible are the greatly increased demands from industry, installation of air conditioning systems, supplemental irrigation, and increased population.

The principal problems of ground water use are the limited available supplies in some sections, decline of head and yield, and encroachment by salt water.

The important surface water problems are pollution, floods, and periods of low flow. An additional problem is the need for extension and enlargement of present water supply facilities in a large number of communities. Water supply systems, particularly filtration plants, have not kept pace with the growth of population and industry.

Pollution is primarily a surface water problem, although serious ground water pollution occurs in Florida and other limestone areas. The three main sources of pollution are municipal sewage, industrial wastes, and silt from soil erosion. Practically all the major streams in the Southeast are polluted to some extent; a number of them seriously. Above the Coastal Plain, silt pollution is almost a universal problem. It is particularly serious in the Piedmont Plateau.

Pollution of any kind damages recreational values, destroys aquatic life, and endangers public health. Some industrial wastes are highly poisonous and corrosive.

In many parts of the Piedmont section, soil erosion is contributing silt to stream channels faster than the streams can carry it away. The resulting channel fill has inhibited the drainage of a large portion of the bottom lands to the point where they are too wet for agricultural use. Many acres of flood plains are also being damaged by deposits of coarse, infertile sediment. Sediment fill has destroyed or is destroying the usefulness of many reservoirs. The cost of filtering water for domestic and industrial use is increased by excessive sediment. Sediment deposits contribute to the maintenance cost of river and harbor works, drainage, and irrigation projects.

The more important water problems are summarized by states below: (5) (7) (8)

Alabama. At Mobile, pumping for air conditioning has lowered the shallow aquifer below the river level and induced infiltration from the brackish Mobile River. Overdraft by closely spaced wells has seriously lowered water levels at Montgomery and possibly at Selma. The Black Warrior River is seriously polluted from Birmingham to beyond Tuscaloosa.

Florida. Although water supplies are generally abundant, local problems have developed in many parts of Florida. Pumpage at St. Petersburg and Tampa has lowered the water table enough to allow salt water to contaminate a considerable portion of Pinellas County. At Miami, lowering of water levels brought about largely by drainage has caused salt water contamination through the tidal canals. Salt water encroachment through canals and tidal streams, induced largely by excessive pumping and drainage, has occurred at Pensacola, Panama City, Fort Myers, Fort Pierce, Stuart, and several other coastal localities. In the Sanford and Indian River areas pumping for irrigation has brought about contamination from naturally salty artesian water. Disposal of sewage, citrus and industrial wastes into limestone aquifers has polluted ground water supplies in a number of areas. Wide fluctuation of surface supplies, seasonal droughts and floods, are a serious problem in the Everglades. Pollution of recreational beaches is serious in several coastal areas.

Georgia. The rapid industrialization and municipal growth of north Georgia, an area of limited ground water supply, has necessitated an expansion of water facilities; largely by impounding surface water. Large amounts of water are wasted from uncontrolled flowing artesian wells in the southeastern part of the state. The artesian head at Savannah has been lowered more than 100 feet by excessive pumping.

Kentucky. Floods are a major problem along many Kentucky streams. Low flows often occur during the summer months. The Ohio River is badly polluted. Ground water supplies are limited over most of the state. Louisville had very serious ground water depletion resulting from overdraft. This situation is now largely corrected by conservation measures. Some ground water pollution occurs in the limestone areas. Pollution from acid mine waste occurs in the mining sections.

Mississippi. Floods cause damage along the Yazoo, Tallahatchie, Tombigbee, Pearl, and Leaf Rivers and many other streams in the state. There is serious sedimentation damage to bottomland areas. Pollution occurs at Jackson, Meridian, Laurel, and near Gulfport. Ground water levels have declined locally from overdraft, and there has been some salt water encroachment along the coast. Uncontrolled flowing wells cause considerable water waste.

North Carolina. Pollution, floods, and damages related to sedimentation are the most important water problems in North Carolina. Serious pollution occurs in the Roanoke, Dan, Yadkin, Neuse, Cape Fear, French Broad, Tuckasegee, Pigeon, and North Toe rivers. The water supply systems of many communities are inadequate to meet present day water needs. Ground water and surface water are scarce in some localities.

South Carolina. Flooding is a problem along many rivers and streams. Excessive sediment fills reservoirs and stream channels and damages surface waters. Salt water encroachment occurs in the Georgetown, Beaufort, and Charleston areas. Water levels have declined at Georgetown and Florence. Ground water is scarce above the Coastal Plain. Many flood plains need drainage.

Tennessee. Floods, pollution, and scarcities of available water are major problems in Tennessee. Ground water supplies are limited over most of the state. Seasonal low flow is a problem in the limestone sections. Pollution occurs in the Cumberland and Tennessee rivers and many of their tributaries. Water levels have declined about 50 feet at Memphis.

Virginia. Floods, pollution, sedimentation, and seasonal low flows are problems in Virginia. Pollution is serious on the James, Roanoke, South Fork Shenandoah, North Folk Holston rivers and several other streams. Water supply facilities are too small for present and future requirements at a number of communities. Valuable oyster beds have been condemned because of pollution.

Legal Aspects of Water Use

Water Rights. The abundant water supplies of the Southeast have kept controversies over water rights at a minimum. Consequently, laws affecting the use of water are meager. Usually the riparian doctrine applies to the use of surface water and English common-law applies to ground water. In general, the common-law riparian doc-

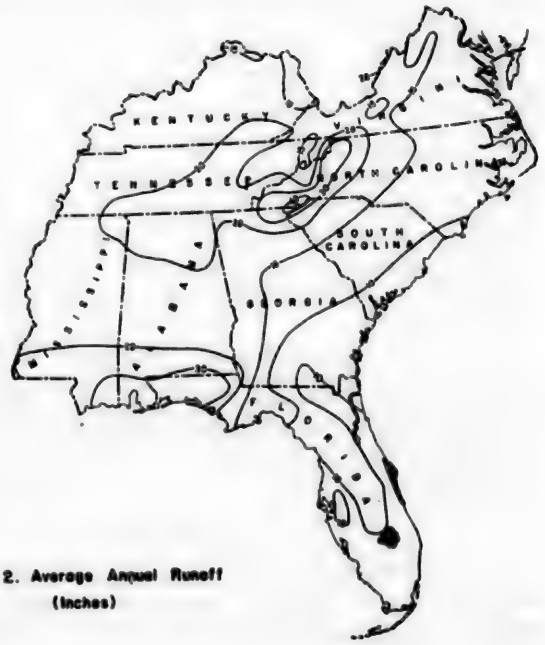

Figure 2. Average Annual Runoff (Inches)

trine is interpreted to entitle the landowners adjacent to a stream to use of the stream, limited to a reasonable use or equitable share with owners downstream.

There is little or no specific state law governing diversion of surface water in this section. South Carolina and Virginia have enacted effective legislation regulating pollution of both surface and ground water. Artesian flow and withdrawal is controlled in parts of Florida.

Until recently little attention has been given to control and use of ground water. Three major concepts are in use regarding ground water rights. The oldest is the English common law doctrine whereby a landowner may take water from under his own land as much as he pleases without regard to the rights of others. Under this law there can be no legal control of ground water. It is satisfactory only where water demand is considerably less than the available supply.

The second doctrine is the American doctrine of reasonable use, first advanced in New Hampshire in 1862. Under this law a person is restricted in the use of ground water to beneficial use on his own land having due respect for his neighbors' similar rights. A more recent form of the rule of reasonable use is the so-called doctrine of correlative rights. This rule provides that in cases where there is not enough water for all, that it be apportioned on the basis of the area of land held by each user.

The third doctrine is that of prior appropriation. Under this law, water is considered as public property and is subject to appropriation for beneficial use. Under this rule land ownership does not give inherent right to water. Water right is acquired by appropriation for beneficial use. The earliest appropriation has the first right and all subsequent appropriations are subordinate to the previous one. This rule protects the early users against late comers. This last doctrine is recognized only in parts of the West (2) (5) (6) (7).

Pollution. In the Water Pollution Control Act of 1948 (Public Law 845) the Federal Government adopted the principle of financially assisting states, interstate agencies and local groups in the construction of sewage treatment plants. This act declares it a congressional policy to recognize the primary responsibilities and rights of the states in controlling pollution. Under the statute the government has no powers to enforce other than to hold public hearings on pollution violations. If pollution continues in violation of the recommendations of the public hearings, the Federal Security Administration, with the consent of the state involved, may bring suit to secure abatement. The Fish and Wildlife Service and the Bureau of Mines have authority to investigate pollution in relation to wildlife. There are several statutes authorizing the Secretary of the Army to control the deposit of refuse matter in navigable waters. State water pollution control agencies have been set up in most of the Southeastern states. A few interstate pollution control commissions have been formed. In several cases local groups have been organized to combat specific pollution problems (7).

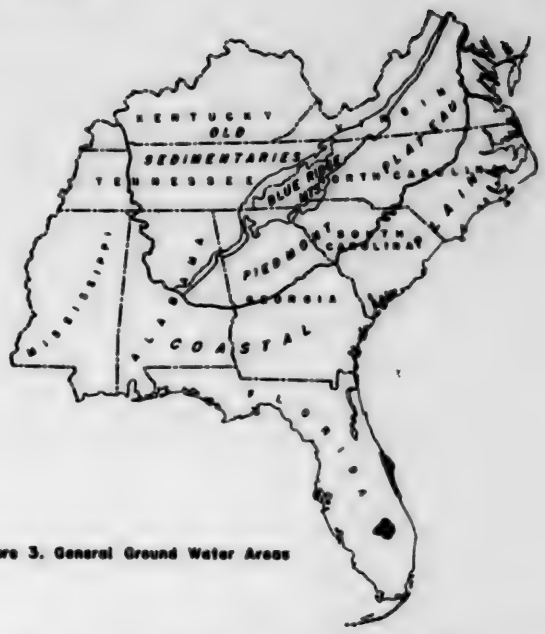

Figure 3. General Ground Water Areas

Conclusions

Unquestionably, there is need for a better understanding, sound development, and protection of our water resources. The constantly increasing use of water will, in time, necessitate some sort of conservation and regulation. The rapidly expanding population and industrial development of the Southeast will inevitably lead to serious problems of pollution and overdevelopment unless sound preventive measures are undertaken. A concerted effort should be made to anticipate these problems.

Efficient and complete development of water resources cannot be accomplished without a better understanding of their occurrence, quantity, quality and availability. Additional studies are needed to secure this information.

Ground water and runoff records are too short and inconclusive to reflect the effects of man's activities on water supply. In this area of excessive precipitation, cultural practices seem less important to water supply than the methods of developing and using water. There are cases where misuse of the land has caused a permanent lowering of the water table. Usually deep gullies have the same effect as drainage ditches and will lower ground water levels wherever they occur (Figure 4). Stream channels filled with erosional debris have the opposite effect of raising water levels.

The declines in head which occur at several places throughout the region do not mean there is less ground water today than formerly. In this section, at least, declines are a local condition which occur when the rate of pumping exceeds the rate of recharge to that area. Head will continue to be lowered in these areas until pumpage is balanced by the rate of inflow to the area.

Water supplies should be developed to insure a perennial supply. Water conservation can do much toward eliminating local problems of overdevelopment of ground water. The elimination of waste from flowing wells, whether by voluntary action of the owners or by action of district and state agencies, will result in increased artesian pressure. Prohibiting overpumping, reclaiming used water for artificial recharge of aquifers, better disposal of wells—all will aid in water conservation.

The increased pressure of population and industry on ground water resources makes legal control of ground water almost inevitable. This fact should be faced in a practical way and the proper action taken before emergencies develop similar to those which have already taken place in other parts of the country. Much of the existing law is unsound largely because of lack of understanding of hydrologic principles. Legal rights are poorly defined and need clarification. It may be that the doctrine of appropriation offers the most satisfactory answer to equitable use and maximum ground water development.

Pollution abatement should be made a part of any water resources development program. It is essentially a problem that can be solved only by public action and support. Effectiveness depends on local, state, and federal cooperation. State legislation for the control of pollution is diverse. Several states have effective water pollution control legislation while others do not. However, even where pollution law is adequate, enforcement of the law is often difficult and unpopular. Public enlightenment as to the importance of the problem will do much toward correcting the situation.

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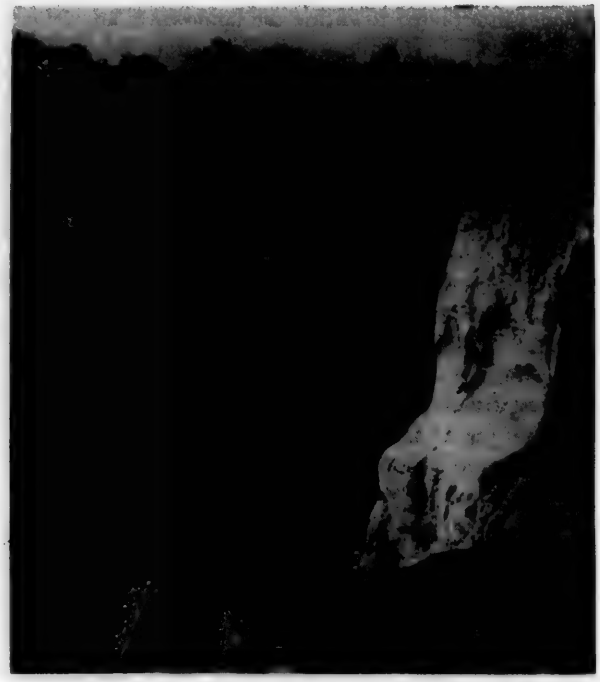

Figure 4. This huge gully in southeastern Georgia is more than 100 feet deep. Gullies have the same effect as drainage ditches and if deep enough will lower ground water levels.

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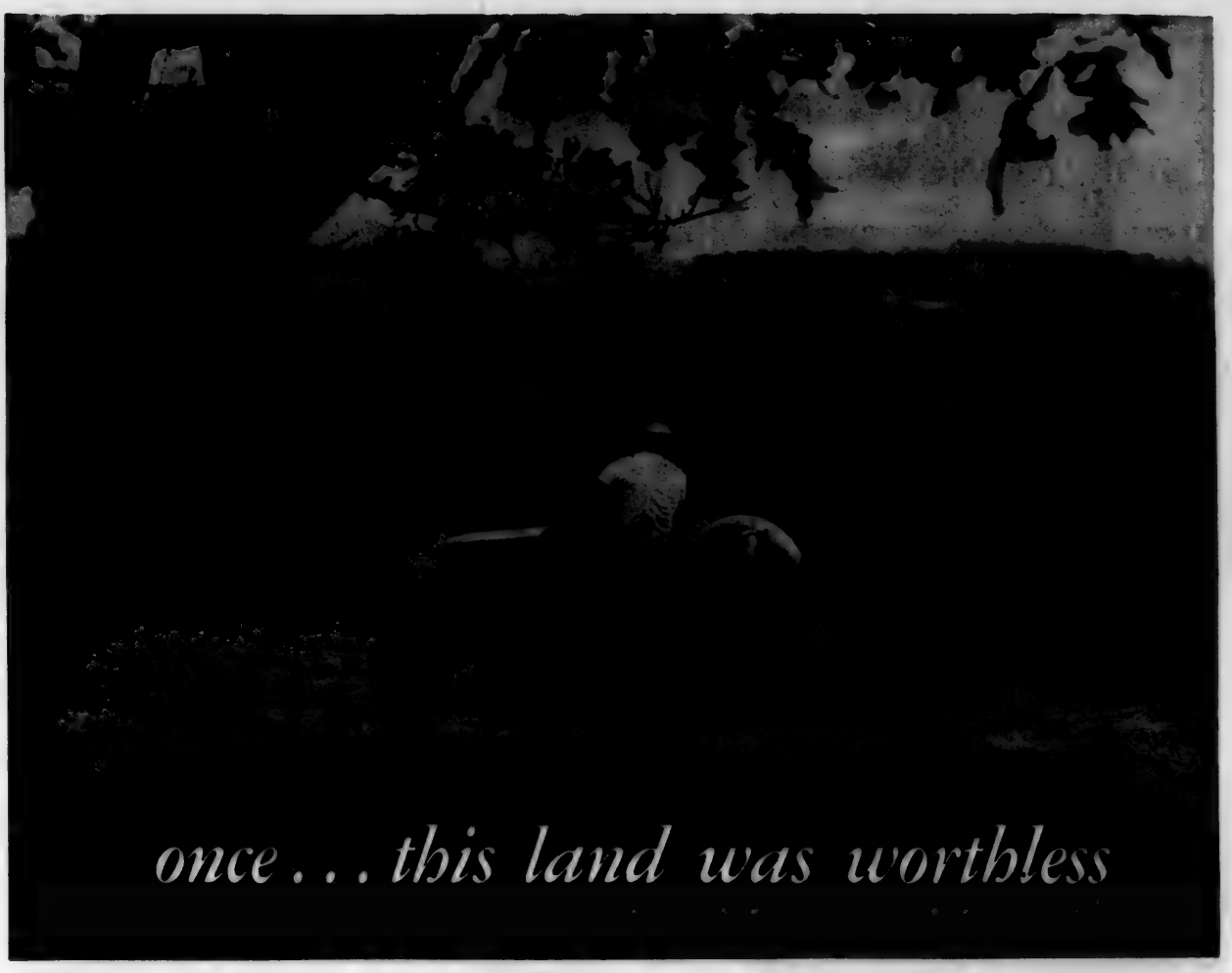
Our Soil: American Heritage

The soil is the heritage of our Nation. We are only its custodians for a brief span of time.

The soil is our most priceless possession; protecting it is our greatest responsibility. Freedom has never flourished in an impoverished land.

God grant us intelligence to respect our soil, and the world to conserve it in all ways, so that when our period of stewardship is done, we may pass on the soil with its fertility and fruitfulness undiminished. Thus, our children's children and their children's children shall not know want, and their Nation will remain the land of plenty and the home of freedom.

—Charles W. Sweet



This rolling meadowland, knee-deep in lush grasses, was barren and desolate not too long ago . . . worn out by successive generations of neglect and one-crop farming.

But, what men have destroyed by their ignorance, other men can restore through their knowledge and devotion.

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Book Reviews

WORLD RESOURCES AND INDUSTRIES. *By* Erich W. Zimmerman. *Harper and Brothers, New York. 831 pages. 1951.*

A fundamentalist and foremost authority on the subject, Professor Erich W. Zimmerman aptly prefaces his monumental work on resources and economics with these remarks: (1) a fuller and clearer presentation of my functional or operational approach to resources: (2) a better organization of all the materials presented, especially of individual chapters; and (3) the inclusion of thoroughly up-to-date statistics and other factual data. Thus, in the author's own words and in the subtitle, A functional appraisal of the availability of Agricultural and Industrial Materials, this great work in the field of economics is briefly summarized.

His original textbook on the subject of resources economics was published in 1931, but, as the author points out, the last two decades have changed the appraisal on our national resources, that former precepts are no longer of any value. In his style, Professor Zimmerman has so ably woven together basic economic factors, of value, labor and capital with the allied social sciences—geography in all of its aspects, human, social, cultural and economic, that this treatise is elevated above the class of a textbook into the realm of general reading for every businessman, student, farmer and soil technician interested in the conservation of our resources. Anyone who wants to take the time to read this wealth of economic information will find fundamental, accurate and interesting revelations which should prove to enlighten them as to the true goal of all conservation.

Developing the theory of conservation of energy, Professor Zimmerman explains how this concept is related to the field of agriculture, foodstuffs, petroleum, chemical, textile, and forest industries. In explaining how resources appraisal has affected all phases of human life, the author says, *"Attitudes toward conservation are radically affected by one's faith or lack of faith in economic doctrine, by his general outlook on life, by his social philosophy, and in particular by his reliance on laissez faire or on social control."* In his attempt to answer these phases of the problem, he deals in specifics, and appears to have reached a sound and logical conclusion, that *"The problems of resource adequacy for the ages to come will involve wisdom more than limits set by nature."*

—Clifford E. Briggs, *Cleveland, Ohio*

LAND OF PLENTY. *By* Bert S. Gittins. *Farm Equipment Institute, 608 S. Dearborn Street, Chicago 5, Illinois. 64 pages. 1951. 25 cents.*

"Land of Plenty" tells how the man on the farm has progressed from a muscle worker commanding only 1.6 horsepower in 1870, to a director of engines and machinery, commanding 33 horsepower. It lists nearly 150 major milestones in the history of American farm mechanization—the most complete list ever compiled.

Most of the book is devoted to the evolution of farm machinery by jobs: soil preparation, planting and cultivating, harvesting, making hay and forage. A chapter on specialized equipment tells of the origin, growth and importance of machinery such as sprayers, pumps, barn equipment, separators and milking machines. There is also a section on tractor power development.

One chapter deals with the size and scope of the industry. Tables show the reduction in man-hours required to produce crops as machinery became more efficient. Also included is a list of 222 member companies of the Farm Equipment Institute.

The book tells of "Fifty Dark Centuries—Then Light." It quotes a former Secretary of Agriculture: "Could a farmer of the Pharaohs' time have been suddenly reincarnated and set down in our grandfathers' wheat fields, he could have picked up the grain cradle and could have gone to work with a familiar tool at a familiar job."

Then, in a little more than a hundred years, a miracle changed agriculture from the age of homespun to the age of power—from self-sufficient, produce-for-yourself type of farming to a commercial operation where each agricultural worker grows enough food and fiber to support fifteen persons. "From Flail to Freedom" is a chapter that traces harvesting from the sickle, at least 1500 B.C., to the modern achievement of mechanical cotton harvesting. "All Flesh Is Grass" outlines step-by-step developments in hay and forage machinery, which only in recent years began to remove the pitchfork and corn bundle labor from the backs of men.

"Land of Plenty" is more than a history book. It explains the continuing difference between the United States, land of abundance, and the rest of the world where more than a billion humans never get enough food for health—and only three out of ten can be considered well fed.

Why is the United States favored? In terms of land per person, the book tells us we are only average, and our population is increasing rapidly. The answer is explained in this action story of free competition—the tangible results of American freedom.

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THE CONSERVATION OF GROUND WATER. *By* HAROLD E. THOMAS. *McGraw-Hill Book Co., Inc., New York, Toronto, London. 1951. 327 pages $5.00.*

Mr. Thomas has done a very exhaustive and thorough investigation and is to be commended on the quality of his contributions. Especially considering the sketchy nature of available knowledge and basic data on ground water, he has presented a well-documented picture of ground-water problems throughout the United States, with numerous illustrations of special cases. These illustrations will be useful to students of water resources, as a convenient source of summarized information on the kinds and extent of ground-water problems.

In his introduction the author has done a masterful job of summarizing the principles and problems associated with the ground-water resource—in fact, the introduction gives an excellent thumbnail sketch of the book as a whole. As an example, Mr. Thomas classifies the major problems of ground-water management in three categories, which form the backbone of later analyses in the text:

"Some problems pertain to entire ground-water reservoirs, where the rate of replenishment is inadequate to meet the continuing demand. In this report these are classified as reservior problems. The second type, classed here as pipeline problems, arises because of the inability of water to move rapidly enough through earth materials to supply the demand of wells, even though the ground-water reservoir as a whole may have an adequate supply of water. The third type occurs along watercourses, where there is an intimate relation between the water in the stream and that pumped from wells. These are the watercourse problems." (Introduction, page 4)

To the forester or soil conservationist, the most interesting discussions in the book have to do with "ground-water problems resulting from land occupancy." Mr. Thomas has made a carefully thought-through appraisal of our current knowledge on the effects of land use and misuse on ground-water resources. Even so, he is left without a clear case: largely because complete evidence on these effects has not yet been built up in the United States. In order to document his discussions more adequately, the author might have been rewarded by a search into European literature on the realization of water to land use. Much of this knowledge is summarized in Zon's "Forests and Water in the Light of Scientific Investigation."

At various times over the years of argument regarding the effects of human occupancy on water resources and soil erosion, comparisons have been made between "accelerated" and "geologic" rates of erosion. While

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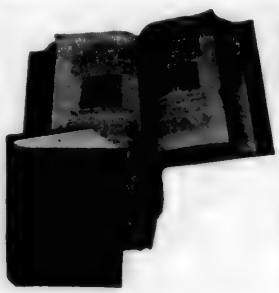

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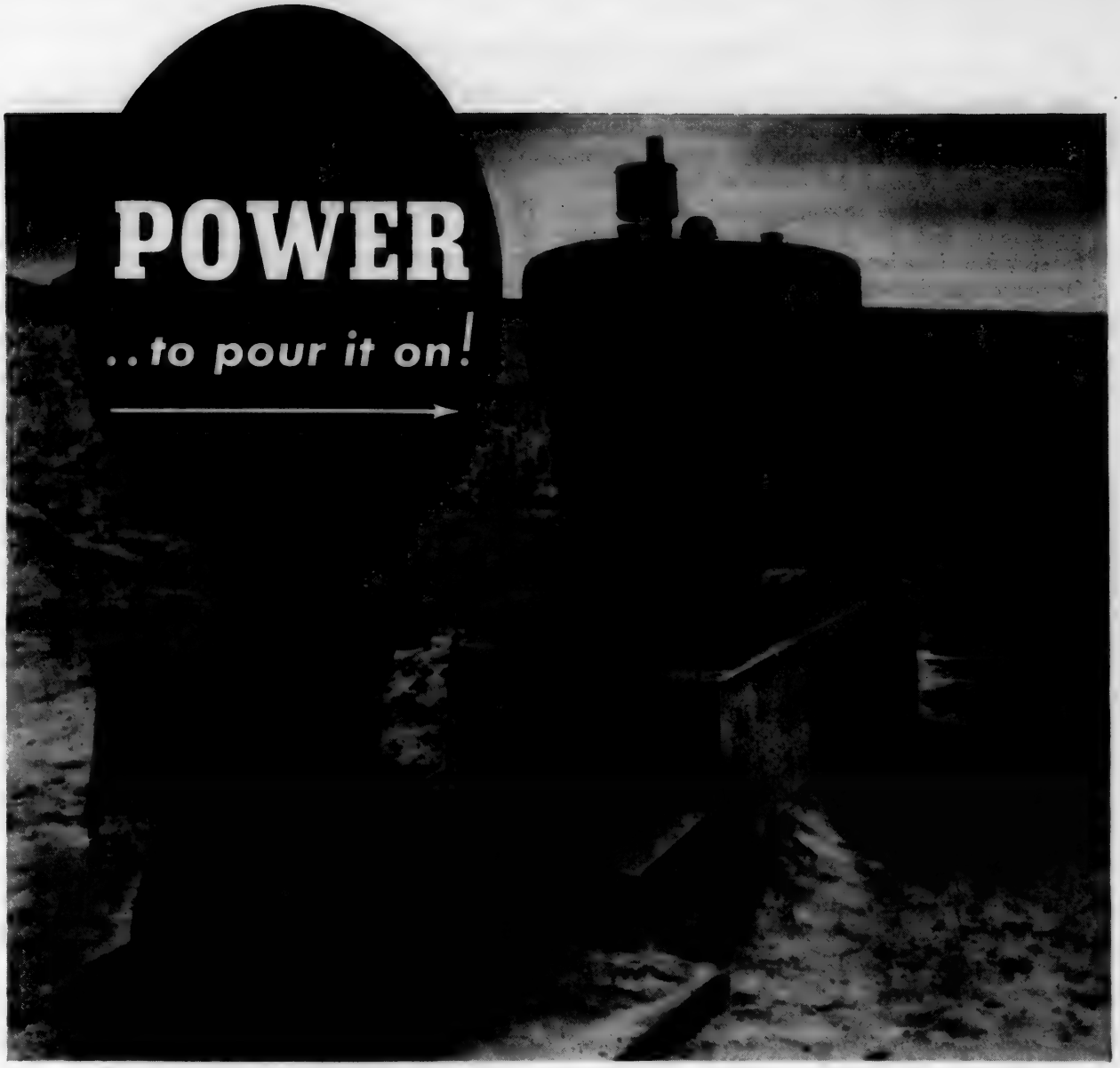

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Mr. Thomas is unbiased in his appraisal of these relative effects, some of his statements deserve further comment. On page 183, for example, is a comment on conditions in the Wasatch Mountains of Utah: "Recent geologic studies have shown, however, that geologic, topographic, and climatic conditions were favorable for such flows long before man appeared on the scene." Of course aggradation and degradation have been going on throughout geologic history. But civilized man is fortunate that he does not have to attempt the maintenance of his culture in the environment of floods and erosion that existed in the post-glacial period. Right now, judging from the development of soil mantles, we are occupying a quiescent moment in the earth's history —although we are doing our best to upset the equilibrium through our own efforts.

In Chapters five and six the author draws a skillful picture of the Nation's large and constantly increasing demands for water. He suggests the role that ground-water resources may occupy in meeting future demands, and then outlines the necessary steps which must be taken to achieve better ground-water management. These discussions are weakened by a lack of focus on important recommendations, and by the intermixing of problems with necessary programs of development. Legal problems, for example, might well have deserved a separate chapter, with more voluminous attention than could be devoted to them as an incidental feature of "Future Needs."

In Dr. Wolman's chapter on "Better Ground Water Management," he summarizes the three major elements of good management. These are:

1. *A management program which will control withdrawals of water, so that "a water budget, balanced on the basis of long-term averages rather than annual replenishment, may be maintained."*
2. *Natural and artificial recharge of important ground-water reservoirs. This will include controlled recharge by manipulation of water supplies, and improved programs of land use and management of recharge areas.*
3. *Importing or supplementing by other means water for recharging underground reservoirs.*

As Dr. Wolman comments, "In all of these endeavors the controlling principles are clear and simple. The practices translating such principles into action are complex and difficult." This points up the fact that ground-water management, like land management, involves complex social problems whose solution requires adjustments in the habits and environments of people, as well as the physical problems which only call for technical skill and financial expenditures.

—H. G. WILM, *Washington, D. C.*

DOWN THE RIVER. *Published by The* SOIL CONSERVATION SOCIETY OF AMERICA. *1016 Paramount Building, Des Moines, Iowa. 16 pages. 1951. 10 cents.*

A new booklet entitled, *"Down the River"* prepared by the Soil Conservation Society of America, reveals in graphic form the devastating losses being suffered by the nation as a result of erosion and waste by our natural resources. It vividly describes in 16 illustrated pages the destructive action of uncontrolled water, and what can be done about it. Taking account of the dollar cost to every American man, woman, and child, improper land management and wasted resources means higher and higher prices for products of the land for all of us.

"Down the River" carefully describes what has been done, and what can be done to halt this waste. It presents a program that places the responsibility where it belongs—on each of us, whether we live in the city or on the farm.

Soil and Water Conservation Glossary

The glossary of soil and water conservation terms which appears on the following pages is the first of four sections. The remaining three sections are scheduled to appear in the April, July, and September issues of the Journal.

Reprints of each section of the glossary are to be made following publication. These will be found in book form and made available to members of the society and other interested persons.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, AND CIRCULATION REQUIRED BY THE ACT OF CONGRESS OF AUGUST 24, 1912, AS AMENDED BY THE ACTS OF MARCH 3, 1933, AND JULY 2, 1946 (39 U.S.C. 233)

Of JOURNAL OF SOIL AND WATER CONSERVATION, published quarterly at Baltimore, Maryland, for October, 1951.

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Publisher, Soil Conservation Society of America, 3110 Elm Ave., Baltimore 11, Md.
Editor, Walter C. Gumbel, Watson Bldg., Fairmont, W. Va.
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Sworn to and subscribed before me this 19th day of November, 1951.
ENOS PRICE
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SOIL AND WATER CONSERVATION GLOSSARY

Prepared by

THE SOIL CONSERVATION SOCIETY OF AMERICA

This glossary consists of terms used in the field of soil and water conservation. It includes terms which belong solely to this field of science and a limited number from closely related fields. The choice of terms from the related fields is restricted to those having special importance or frequent use in soil and water conservation language.

This compilation is primarily for members of the Soil Conservation Society of America and others who are professionally engaged or interested in land use, soil and water conservation work. It should be useful as a reference list and as a guide in usage of soil and water conservation terminology.

In 1946, a few years after the active organization of the Soil Conservation Society of America, the Executive Council recognized the need for an up-to-date compilation of terms. A Glossary Committee was appointed and charged with the responsibility of constructing a glossary. As a precedent the Soil Conservation Service, U.S.D.A., had prepared a glossary in mimeograph form in 1936. This was primarily for use within the Service.

The Committee, under the chairmanship of Mr. Edward M. Simmons from 1946 to 1950, began its work by collecting terms and definitions. These were tentatively assembled in 1947 and again in 1948. The final selection and editing of the terms was done in 1951. Each member of the 1951 Committee made a critical review of terms in the phase of soil conservation work which he was particularly qualified to edit. Later each member reviewed the complete work.

This is the first glossary of soil and water conservation terms published by the Soil Conservation Society of America. A revision will surely be needed within a few years to bring the contents up to date and to correct any fallacies in the present work. The material in this glossary was assembled with care by consulting many references and obtaining many verbal opinions. Nevertheless, omissions and incomplete definitions are apt to be found—for this the Committee asks lenient judgment on the part of the readers. It also asks that errors and omissions be brought to the attention of the Glossary Committee or the secretary of the Society. This will help in making a revision.

The Committee in 1951 set these standards for the contents of the glossary:

1. Include only words and terms which specifically apply or are closely related to land use, soil and water conservation.
2. Include a minimum of highly technical terms from other specific fields of science. (The aim was to include the scientific terms which the average soil conservationist needs to know or is likely to find in soil and water conservation literature. Technical specialists and researchers will find this glossary useful, but in addition they will have to turn to glossaries and texts in other fields of science.)
3. Define terms only in their application to soil and water conservation. (In special cases a parenthesis is used after the term to insert the field of interest, example ABSORPTION LOSS (Irrigation). This is to call particular attention to the use of a term in a special field or phase of soil and water conservation or to show that the term is defined in only one branch or field of interest.

   A limited amount of exposition is added to some of the definitions to give a more complete explanation or to show application of the term.)

As indicated above, the Committee since 1946 made use of many reference books and other publications in the course of its work. It would be impossible to list all the sources of information on which so large a part of this glossary is grounded. The following references, however, can be listed as particularly useful:

Agricultural Geology, F. V. Emerson. Revised by J. E. Smith.
John Wiley & Sons, New York, N. Y., 1928

Descriptive Catalog of Conservation Practices. Mimeograph No. 417a-41782. Soil Conservation Service, U.S. Dept. Agriculture

Dictionary of Geological Terms. C. M. Rice
Edwards Brothers, Ann Arbor, Mich., 1940

Elements of Soil Conservation. H. H. Bennett
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Engineering Terminology. Brown and Runner
Gillette Publishing Co., Chicago, Ill., 1939

Feeds and Feeding, Abridged. F. B. Morrison
The Morrison Publishing Co., Ithaca, N. Y., 1949

Forest Terminology
Society of American Foresters, Washington, D. C., 1950

Fundamentals of Soil Science. Millar and Turk
John Wiley & Sons, New York, N. Y., 1951

Glossary of Terms used in Soil Conservation. Mimeograph, Soil Conservation Service, U.S. Dept. Agriculture, 1936

Hydrology Handbook, Manual of Engineering Practices No. 28
American Society of Civil Engineers, New York, N. Y., 1949

Plant Ecology. W. B. McDougall
H. Kempton, London, 1949

Plant Ecology. Weaver and Clements
McGraw-Hill Book Co., New York, N. Y., 1938

Range Conservation Glossary, Mimeograph, Soil Conservation Service, U.S. Dept. Agriculture, 1944

Soil Conservation. H. H. Bennett
McGraw-Hill Book Co., New York, N. Y.

Soils and Men
Yearbook of Agriculture, U.S. Dept. Agriculture
Supt. of Documents, U.S. Government Printing Office, 1938

Technical Guide for the Management of Soils, Field Crops and Pastures in Minnesota. Mimeograph, 1946
Soil Conservation Service, U.S. Dept. Agriculture

Weather Glossary—1945
Weather Bureau, U.S. Dept. Commerce
Supt. of Documents, U.S. Government Printing Office, 1946

The Committee gratefully acknowledges the information obtained from these publications and any others used in the search for authentic material.

In the five years since 1946 numerous members of the Society and some others spent many hours of work selecting and preparing material. The names of all contributors are not known, but it is appropriate to list here the men who gave help by serving on the Glossary Committee for a year or more at some time prior to 1951, namely, W. A. Rockie, B. W. Allred, E. A. Norton, L. A. Hawkins, R. W. Musser, A. M. Hedge, D. A. Dobkins, Phillip Allan, F. A. Fisher, Paul Tabor, F. E. Bear, C. W. Domby, H. H. Krusekopf, W. H. Danley, J. H. Christ, W. B. Kemp, Robert Gardner, W. Chase, W. O. Collins, R. O. Lewis, and B. Robinson. The Committee sincerely thanks these men and all others who helped in any way with the development of this glossary.

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December, 1951

A

Absorption Loss *(Irrigation)*—The initial loss of water from a canal or reservoir by capillary action and percolation at the time water is first turned into the structure.

Accelerated Erosion—Erosion of soil material at a rate greater than that of normal erosion. Erosion more rapid than that which existed under natural conditions. Accelerated erosion occurs as a result of destruction of vegetal cover or of some activity of man. It may consist of any of the recognized types of erosion such as sheet erosion, rill erosion, gully erosion, wind erosion, or landslides, or combinations of them.

Acid Soil—A "*sour*" soil, containing more hydrogen than hydroxyl ions. Precisely, a soil with a pH of less than 7.0. For practical purposes, a soil with a pH below 6.6.

Acre-foot—The quantity of water, soil or other material that will cover one acre one foot deep.

Acre-inch—The quantity of water, soil or other material that will cover one acre one inch deep.

Adobe—A fine calcareous clay or silt of aeolian, or wind-blown, origin. Sometimes puddled, molded and dried to make adobe bricks used in construction.

Aeolian *(eolian)* Soil Material—Parent material of soil accumulated through wind action. Commonly refers to sandy material usually in dunes.

Aeration, Soil—The process by which air and other gases in the soil are renewed. The rate of soil aeration depends largely on the size and number of soil pores and on the amount of water clogging the pores. A soil with many large pores open to permit rapid aeration is said to be well aerated, while a poorly aerated soil either has few large pores or has most of those present blocked by water.

Aerial Photograph—A photograph taken from the air. Vertical photographs, taken with the camera pointed directly downward, are used widely for mapping land conditions and land use, and for many other purposes. Oblique photographs, taken with the camera pointed at an angle from the vertical, are used for some purposes. Multiple-lens cameras make a vertical exposure and two or more oblique exposures at the same instant. An aerial photograph differs from a map, because on a photograph each ground point other than the center is displaced from its true position because of the relief of the ground. The science or art of obtaining surveys (and hence maps) from photography is called *Photogrammetry*.

Aftermath—The regrowth of forage crops after harvesting.

Aggradation—The building up of any portion of the earth's surface toward a uniformity of grade or slope by the addition of material; especially the deposition of sediment in the beds of streams, and on the floors of bodies of standing water.

Aggregation, Soil—The tight cementation or binding together of a number of individual soil particles into a secondary unit, aggregate or granule. The water-stable aggregates, which will not disintegrate easily are of special importance to soil structure.

Agronomic Practices—The methods used in the production, processing and use of farm crops, such as selecting seed, seed bed preparation, fertilizing, liming, manuring, seeding, cultivation, harvesting, curing, crop sequence, crop rotations, cover crops, strip cropping, pasture development, etc.

Alkali Soil—A soil that has so high a degree of alkalinity, or so high a percentage of exchangeable sodium, or both, that the growth of most crop plants is reduced. This is true if the pH is 8.5 or higher, or if the percentage of exchangeable sodium is 15 per cent or more. The soil is highly dispersed so that air and water movement is very slow. In popular usage, saline soils have often been called "white alkali." True alkali soils, because of dispersion of the organic matter, have been called "black alkali." Contrast with *Saline Soil*.

Alkaline Soil—A non-acid soil which contains more hydroxyl ions than hydrogen ions. Precisely, a soil having a pH above 7.0; for practical purposes, with a pH above about 7.3. Not to be confused with "alkali soil."

Alluvial Fan—A fan-shaped deposit of sand, gravel and fine material dropped by a stream where its gradient lessens abruptly. Alluvial fans range in size from very small deposits formed at the base of a small cliff after one rain to large areas containing many square miles at the base of a mountain range.

Alluvial Soil—Soil developed from transported and relatively recently deposited material (alluvium) characterized by little or no modification of the original material by soil-forming processes.

Alluvium—Sediments, usually fine materials, deposited on land by a stream.

Anchor-ice—Ice that forms on the bed of a stream.

Angle of Repose—The maximum slope or angle at which a material such as soil or loose rock remains stable. When exceeded, mass movement by slipping as well as by water erosion may be expected. Syn. *Critical Slope.*

Animal Unit—A measure of livestock numbers by which kinds, classes, sizes, and ages are converted to an approximate common standard in relation to feed and forage resources based on the equivalent of a mature cow (approximately 1,000 lbs. live weight). In western range territory, an animal unit is roughly one head of cattle, one horse, one mule, five sheep, five swine, or five goats—a suitable average of the generally lower ratio between these kinds of livestock on the range and the higher ratio in the feed lot.

Animal Unit Month—A measure of forage or feed requirement to maintain one animal unit for a period of 30 days. Abbr. *A. U. M.*

Annual Plant—A plant which completes its life cycle and dies in one year or less. A "summer annual" is a plant from spring-sown or summer-sown seed which matures before winter. A "winter annual" is a plant from autumn-sown seed which blooms and fruits the following spring. Contrast with *Biennial Plant; Perennial Plant.*

Antecedent Moisture—The degree of wetness of the soil at the beginning of a runoff period. frequently expressed as an index determined by summation of weighted daily rainfalls for a 10- to 20-day period preceding the runoff in question.

Apron—A floor or lining of material like concrete or timber to protect a surface from erosion; examples, the pavement below chutes, spillways, or at the toes of dams.

Appropriated Rights *(Water)*—See Water Rights.

Aqueduct—A conduit for water, which may consist of a canal, pipe or tunnel or combination of them.

Aquifer—A porous soil or geological formation which yields ground water to wells and springs.

Arched Dam—A curved dam, convex up stream, that depends largely upon arch action for its stability. The load is transmitted by the arch to the canyon walls, or other abutments.

Area Curve *(Hydraulics)*—A graph of the cross-section, surface or other area of a stream, channel, water surface or structure as a function of elevations.

Arid—A term applied to regions or climates which lack sufficient moisture for crop production without irrigation. The limits of precipitation vary considerably according to temperature conditions with an upper limit for cool regions of 10 inches or less and for tropical regions as much as 15 to 20 inches. Contrast with *Semiarid.*

Arroyo—Channel or gully in an arid country, usually with high steep banks, dry much of the time because of infrequent rainfall and not cut deeply enough to reach the level of permanent ground water.

Artesian Water—Water confined under enough pressure to cause it to rise above the level where it is encountered in drilling. Flowing artesian wells are produced when the pressure is sufficient to force the water above the land surface.

Available Moisture—See Capillary Water; Field Capacity; Gravitational Water; Hygroscopic Water.

Available Water Holding Capacity (*Soils*)—The available water holding capacity in surface inches of water per inch depth of soil is equal to the difference between the percentage of water at field capacity and the percentage of water at wilting point, times the volume weight, divided by one hundred.

B

Backfire—In forestry, a fire started intentionally ahead of an advancing fire to remove inflammable material by controlled burning and thus stop or control the main fire.

Bacteria—A large group of unicellular microscopic organisms widely distributed in air, water, soil, the bodies of living animals and plants, and dead organic matter. Most bacteria are either parasitic or saprophytic. Bacteria may cause diseases of plants and animals, fix free nitrogen from the air and cause decay of organic matter.

Badlands—Areas of rough, irregular, denuded land on which most of the surface is occupied by ridges, gullies and deep channels.

Baffle-Pier—An obstruction set in the path of high-velocity water, such as a pier on the apron of an overflow dam, to dissipate energy and prevent scour.

Baffles—A set of vanes, guides, grating, or similar device placed in a conduit to check eddy currents below them, and provide a more uniform distribution of velocities.

Band—Any number of sheep or goats handled as a single unit under range conditions; usually considered as synonymous with *Herd.*

Band Day—The amount of forage required to support a given band of sheep or goats for one day.

Bank Storage—Water absorbed by the bed and banks of a stream and returned in whole or in part as the ground-water level falls.

Basal Area (*Range Management*)—The area of ground surface covered by the stem or stems of a range plant, usually measured one inch above the soil in contrast to the full spread of the foliage.

Base Exchange Capacity—A measure of the adsorptive capacity of a soil for bases or the amount of

bases which can be absorbed by a given amount of soil, expressed in terms of milliequivalents of monovalent cation adsorbed from a neutral solution by 100 grams of soil. Generally speaking, a soil with a fairly high exchange capacity is preferred to one with a low exchange capacity because it will retain more plant nutrients and be less subject to leaching. Also called *Exchange Capacity*.

Base Flow—Stream flow derived from subterranean storage in contrast to flow from surface runoff.

Basin Irrigation—A method of irrigation in which a level area is surrounded by an earth ridge to form a pool when water is applied.

Basin Listing—See Lister.

Bear-Trap Dam—An obstruction built of hinged leaves that are raised and held up by the pressure of water admitted to the inside. The dam is lowered by draining the interior.

Bed Load—Soil, rock particles or other debris rolled along the bottom of a stream by the moving water, as contrasted with the "silt load" carried in suspension.

Bedding, Land—Plowing, grading or otherwise elevating the surface of fields into a series of parallel beds or "lands" with shallow surface drains separating them.

Belanger (*Hydraulics*)—See Critical Depth; Critical Velocity.

Bench Flume—A conduit on a bench cut or constructed on sloping ground.

Bench Mark—A point of reference in elavation surveys.

Bench Terrace—A shelf-like embankment of earth with a level or nearly level top and a steep or vertical downhill face, constructed along the contour of sloping land to control run-off and erosion. Types of the bench terrace are the horizontal bench terrace, which has no measurable slope from the back to the front of the bench, and the sloping bench terrace, which has a signficant slope from the back to the front of the bench. Contrast with *Ridge Terrace*.

Bentonite—A colloidal clay substance with an extremely high swelling property when moistened. It is used for sealing reservoirs and ponds. It has no appreciable structural strength, hence must be used together with sand or soil to support a large head of water.

Biennial Plant—A plant which requires two years to complete its life cycle. Biennials grow from seed in the spring, remain vegetative (often in a rosette) the first year and live through the winter. The second year they produce seeds, mature and die. Some short-lived perennials such as red clover are often erroneously called biennials. Contrast with *Annual Plant; Perennial Plant*.

Bifurcation Gate—A structure that divides the flow between two conduits.

Biotic Influence—The influence of animals and plants on associated plant or animal life as contrasted with climatic influences and edaphic (soil) influences.

Biotype—The most homogeneous population encountered in nature, made up of individuals with identical genetic composition and heredity.

Blowout (*Erosion*)—An excavation in areas of loose soil, usually sand, produced by wind action.

Board Foot—The amount of wood in a board one foot wide, one foot long, and one inch thick; 144 cubic inches, or 1/12 cubic foot.

Border—See Wildlife Border.

Border Dikes—Earth ridges built to hold irrigation water within prescribed limits within a field.

Border Irrigation—An open field method of flood irrigation between border dikes.

Border Strip—An area surrounding and treated the same as a sample plot. Sometimes referred to as *Isolation Strip*.

Bottomland—See Flood Plain

Broad Base Terrace—A ridge type terrace 10 to 20 inches high, and 15 to 30 feet wide with gently sloping sides, a rounded crown, and a dish shaped channel along the upper side, constructed to control erosion by diverting run-off along the contour at a non-scouring velocity. It may be level or have a grade toward one or both ends. See *Ridge Terrace*.

Broadcast Seeding—Scattering seed on the surface of the soil as contrasted to drill seeding which places the seed in rows in the soil.

Broad-Crested Weir—An overflow structure on which the nappe is supported for an appreciable length in the direction of the stream.

Browse—Twigs or shoots, with or without attached leaves, or shrubs, trees, or woody vines available as forage for livestock and wild animals.

Browsing Line— A line marking the height to which browsing animals have removed the foliage from shrubs and trees.

Brush Matting—(1) A matting of branches placed on badly eroded land to conserve moisture and reduce erosion while trees or other vegetative cover is being established. (2) A matting of mesh wire and brush used to retard streambank erosion.

Brush Pasture—Pastures with a natural cover of trees and shrubs, where a considerable portion of the food obtained by livestock comes from browsing woody plants.

Buffer Species (*Wildlife*)—Any animal or plant which may serve as an alternative food and thus reduce pressure on specific food items.

Buffer Strips—Contour strips of grass or other erosion-resisting vegetation between or below cultivated strips or fields.

Buffer Zone (*Range*)—A publicily owned range area adjoining certain privately owned range land, which may be used to supplement the range on the private land.

Bunch Grass—A grass which has a characteristic habit of growing in tufts or bunches. Examples are orchard grass, bluestem and Dallis grass. Contrast with *Sod Grass*.

C

Calcareous Soil—Soil containing sufficient calcium carbonate or calcium carbonate with magnesium carbonate to effervesce visibly when treated with

hydrochloric acid. If the content of magnesium carbonate is high effervescence may be slow to start.

Canal, Main Irrigation — The channel or conduit which conveys water from the point of diversion or storage reservoir to a group of irrigated farms or to lateral or branch canals. The term also applies to canals conveying water from a stream to an off-channel storage reservoir. Also known as *Feed or Storage Canal.*

Canopy—The cover of leaves and branches formed by the tops or crowns of trees or other plants. Its density is ordinarily expressed as the percentage of the ground that would be completely shaded if the sun were directly overhead.

Capability, Land—See Land Capability.

Capacity Curve—(1) A graph of the volume of a structure such as a reservoir or tank as a function of elevations. (2) A graph of the capacity rate of flow in a pipe or conduit or through porous material.

Capacity Formula *(Hydraulics)*—A formula used to calculate the capacity or discharge "Q" of a channel.

$$Q = a\,V,$$

where Q is in cubic feet per second, a is the cross-sectional area of the channel in square feet. and V is the mean velocity of flow in feet per second. (To calculate V, see *Manning Formula*).

Capillary Water *(Soils)*—The portion of soil water which is held by cohesion as a continuous film around the particles and in the capillary spaces. Most of this water is available to plants.

Carrying Capacity—See Grazing Capacity.

Carrying Capacity *(Wildlife)*—The maximum number of a given wildlife species which any given territory will support through the most critical period of the year.

Catch Crop—A crop produced incidental to the main crop of the farm and usually occupying the land for a short period; also a crop grown to replace a main crop which has failed.

Catena, Soil—A group of soils within a soil zonal region developed from similar parent material but differing in drainage or relief. From the Latin for chain.

Centrifugal Pump — A water-lifting device that utilizes the centrifugal force imparted to the water by a rapidly rotating impeller. It is essentially a reversed inward-flow turbine, the water being admitted to the center of the runner and discharged at its outer periphery. It is not a positive action or displacement pump.

Channel—That part of a natural stream where water normally flows or an excavated ditch for the flow of water.

Channel Improvement—The improvement of the hydraulic flow characteristics of a natural or artificial channel by clearing, excavation, or other means in order to increase its carrying capacity. Sometimes used to describe the process of preventing channel erosion.

Chaparral—A dense scrub stand, usually a permanent type, dominated by evergreen shrubs or dwarf trees such as scrub oak and buckbrush.

Check *(Hydraulics)*—A structure designed to raise or control the water surface in a channel or ditch.

Check Dam—A small, low dam constructed in a gully or other watercourse to decrease the velocity of stream flow, for minimizing channel scour and promoting the deposition of eroded material. Usually built of inexpensive and temporary materials where dependence for ultimate protection is placed on vegetative cover.

Check Irrigation—A method of irrigation in which an area is practically or entirely surrounded by earth ridges.

Chemical Gaging *(Hydraulics)*—A process of measuring the flow of water by ascertaining the resulting degree of dilution of a chemical solution of known saturation introduced into the stream at a known rate.

Chezy Formula *(Hydraulics)*—An empirical formula expressing the relation between velocity of water, hydraulic radius, and friction slope.

$$V = C\sqrt{RS}$$

where V = velocity; R = hydraulic radius; S = sine of the slope angle due to friction; and C = a coefficient. See also *Kutter's Formula; Manning's Formula.*

Chiseling—See Subsoiling.

Chute—A high-velocity conduit for safely conveying water to a lower level without erosion from excessive velocities and turbulence.

Cipolletti Weir—A measuring weir in which the bottom of the overflow notch is level and the sides have a slope of 1 horizontal to 4 vertical, to compensate for end contractions.

Clay—(1) Small mineral particles of the soil, less than 0.002 mm in diameter. (2) Soil material containing 40% or more clay, less than 45% sand, and less than 40% silt.

Claypan—A horizon of accumulation or a stratum of dense compact and relatively impervious clay. Claypan is not cemented, but is hard when dry and plastic or stiff when wet. Its presence like that of a true hardpan may interfere with water movement or root development.

Clean Tillage—Cultivation to prevent the growth of all vegetation except the particular crop desired.

Clear Cutting *(Forestry)*—A method of cutting that removes all merchantable trees on the area in one cut. Contrast with *Selective Cutting.*

Climate—The sum total of all atmospheric or meteorological influences, principally temperature, moisture, wind. pressure, and evaporation, which combine to characterize a region and give it individuality by influencing the nature of its land forms, soils, vegetation and land use. Contrast with *Weather.*

Climate, Continental—The type of climate characteristic of land areas separated from the moderating influence of oceans by distance or mountain barriers. It is marked by relatively large daily and seasonal changes in temperature.

Climate, Oceanic—The type of climate characteristic

of land areas near oceans which contribute to the humidity and at the same time have a moderating influence on temperature and range of temperature variation. Also referred to as *Marine Climate.*

Climax ***(Plant Ecology)***—The final stage of plant succession for a given natural environment; the stage at which the composition of the plant community remains unchanged and can reproduce itself as long as the environment remains unchanged. See *Succession.*

Coarse Textured Soil—A sandy soil.

Coefficient of Variation or Variability ***(Statistics)***—The standard deviation expressed as a fraction of the mean. May also be expressed as a percentage.

Coffer-dam—A barrier built in the water so as to form an enclosure from which the water is pumped to permit free access to the area within.

Colluvial Soil Material—Soil material which has moved downhill and has accumulated on lower slopes and at the bottom of the hill. Colluvial material is moved downhill by the force of gravity and to some extent by soil creep, frost action and local wash. Syn. *Colluvium.*

Commensurability ***(Range)***—The extent to which ranches or ranch outfits should share in grazing privileges on nearby public or cooperatively controlled range, as determined by the grass forage resources of privately controlled property of the ranches involved.

Community ***(Ecology)***—A non-technical term which may be applied to any assemblage of organisms growing together in a natural habitat. Examination by careful ecological methods is necessary before any given community can be subdivided into any particular formation, association or faciation. Moreover, all ecological investigators have not given the same rank to equivalent units.

Companion Crop—A crop which is grown with another crop. Usually applied to a small grain crop with which forage crops are sown. The small grain crop may also be known as "nurse crop," but companion crop is the term preferred by agronomists. It may also apply to other crops such as corn and soybeans when grown together.

Compost—An artificial or synthetic manure made by allowing waste plant residues supplemented by lime and barnyard manure or inorganic fertilizers, and generally with some added soil or sod, to undergo bacterial action over a period of several months, or until well decomposed.

Concentrates ***(Feed)***—Feed with high total digestible nutrient and low fibre content; examples, grain and grain by-products.

Conduit—Any channel intended for the conveyance of water, whether open or closed.

Conifer—A plant of the pine family, *Pinaceae;* examples, pines, sprucees, firs, hemlocks, cedars, cypresses, or of the yew family, *Taxaceae;* examples, yew, juniper. Mostly cone-bearing and evergreen, although yew and the junipers have berry-like fruits and the larches are deciduous. Frequently referred to as softwoods, as contrasted with the broad-leaved hardwoods.

Conservation Survey—See Soil Conservation Survey.

Consumptive Use—The quantity of water used and transpired by the vegetation plus that evaporated. Syn. *Evapo-transpiration.*

Continuous Delivery ***(Irrigation)***—A system by which each irrigator receives his allotted quantity of water at a continuous rate. Contrast with *Rotation Irrigation.*

Continuous Grazing—Grazing without interruption throughout the season. Contrast with *Deferred Grazing; Rotation Grazing.*

Contour—An imaginary line on the surface of the earth connecting points of the same elevation; a line drawn on a map to show the location of points of the same elevation. A series of contour lines on a map shows the topography of the land.

Contour Farming—Conducting field operations, such as plowing, planting, cultivating and harvesting on the contour or at right angles to the natural direction of slope.

Contour Furrows—Furrows plowed on the contour on pasture or range land to prevent soil loss and allow water to penetrate the soil. Sometimes used in planting trees or shrubs on the contour.

Contour Interval—The vertical distance between contour lines.

Contour Strip Cropping—The production of crops in comparatively narrow strips planted on the contour and at right angles to the natural direction of slope. Usually strips of grass or close growing crops are alternated with those in cultivated crops. *Graded Strip Cropping* is a form of contour strip cropping in which the strips have a grade of not more than 1% laid out from a guide line in the center of the strip. All rows and furrows are continuous to a grassed waterway. *Graded Strip Cropping* is used on sloping land which is slightly or moderately wet. It serves to control erosion and also provides drainage by allowing surface water to follow the rows at a safe velocity.

Control—(1) In research, something under study, either untreated or given a standard treatment, which is used as a standard for comparison or checking the results of other treatments. (2) In hydraulics, a section or reach of an open channel where conditions exist that make the water level above it an index of the discharge.

Control Flume ***(Hydraulics)***—An open conduit or artificial channel arranged for measuring the flow of water, generally consisting of a raised floor or otherwise constricted section wherein Belanger's critical depth exists. See *Parshall Measuring Flume.*

Controlled Burning—Any deliberate use of fire on land whereby the burning is restricted to a predetermined area and intensity. The intensity of fire is controlled by the time of year, the time of day, and the moisture content of vegetation in the area. Syn. *Prescribed Burning.*

Conveyance Loss—The loss of irrigation water from the delivery system.

Cord—A unit of measurement of wood. In measuring timber 128 cubic feet equals 1 cord; a long cord is 160 cubic feet. The standard cord is a pile of wood 4 by 8 feet made up of sticks 4 feet long.

Core Wall—A wall of masonry, sheet piling, or puddled clay built inside a dam or embankment to reduce percolation.

Corrasion ***(Geology)***—The process by which a flowing substance loaded with abrading material detaches or wears away rock. A stream carrying sand and gravel has power to cause corrasion.

Correction Strip—An irregular strip or area of land lying between contour strips.

Correlation ***(Statistics)***—A statistical method for studying and expressing the degree of association or mutual relationship between variates. Not necessarily a causal or dependent relationship.

Corrosion ***(Geology)***—The process by which surface or ground water dissolves and chemically alters rock materials with which it comes in contact.

Cover, Ground—Any vegetation producing a protecting mat on or just above the soil surface. In forestry, low-growing shrubs and herbaceous plants under the trees.

Cover, Vegetation—All plants, of all sizes and species, found on an area irrespective of whether they have forage or other value. Syn. *Plant Cover.*

Cover Crop—A close-growing crop grown primarily for the purpose of soil protection and improvement, between periods of regular crop production, or between trees and vines in orchards and vineyards.

Cow Month—The feed or forage needed to maintain a mature cow in good condition for 30 days.

Cradle ***(Engineering)***—A footing structure shaped to fit the conduit it supports.

Creep, Soil—Downhill mass movement of soil or the products of weathering at an imperceptible rate, due primarily to gravity.

Crest—(1) The top of a dam, dike, spillway or weir, frequently restricted to the overflow portion. (2) The summit of a wave or peak of a flood.

Crib Dam—A barrier made of timber, forming bays or cells which are filled with stone or other heavy material.

Critical Depth ***(Hydraulics)***—(1) The depth of water in a channel corresponding to one of the recognized critical velocities. Ordinarily used in reference to Belanger's critical depth, which is the depth at which a given flow would attain its minimum energy with respect to the bottom of the channel. (2) The depth at which in a given channel a given quantity of water flows with the minimum content of energy.

Critical Slope—See Angle of Repose.

Critical Velocity ***(Hydraulics)***—The velocity at which some basic change in the nature or effect of flow occurs. There are several such "critical" velocities. The term is most commonly used in reference to Belanger's critical velocity or that velocity at which the energy of the flowing liquid reaches its minimum possible value. Other important critical velocities are those of Reynolds and Kennedy. The upper Reynolds critical velocity is that at which laminar flow changes to turbulent flow. The lower Reynolds critical velocity is that at which turbulent flow changes to laminar flow. Kennedy's critical velocity is that at which neither deposition nor scour occurs in a stream flowing over an erodible bed.

Cropland—Land regularly used for the production of crops (except forest crops and permanent pasture). Rotation pasture, cultivated summer fallow, orchards, and land ordinarily used for crops but temporarily idle is included.

Crop Residue—The portion of a plant, or crop, left in the field after harvest.

Crop Residue Management—See Stubble Mulch.

Crop Rotation—The growing of different crops in recurring succession on the same land.

Crop Tree—An individual tree which, because of species, form, and condition is best adapted for a crop, usually for saw-log purposes. Contrast with *Weed Tree; Wolf Tree.*

Crown ***(Forestry)***—The upper part of a tree including the branches and leaves.

Crown Class—All trees in a stand occupying a similar position in the crown cover. The crown classes usually distinguished are:

Dominant—Trees with crowns extending above the general level of the forest canopy and receiving full light from above and partly from the side; larger than the average tree in the stand and with crowns well developed but possibly somewhat crowded on the sides.

Co-dominant—Tree with crowns forming the general level of the forest canopy and receiving full light from above but comparatively little from the sides; usually with medium-sized crowns more or less crowded on the sides.

Intermediate—Trees with crowns below, but still extending into the general level of the forest canopy, receiving a little direct light from above but none from the sides, usually with small crowns considerably crowded on the sides.

Overtopped—Trees with crowns entirely below the general forest canopy and receiving no direct light either from above or from the sides. These may be further divided into oppressed, usually with small, poorly developed crowns, still alive, and possibly able to recover; and suppressed or dying and dead.

Crown Cover—The canopy formed by the crowns of all the trees in a forest, or, in an uneven-aged forest, by the crowns of all trees in a specified crown class.

Crown Density—The percentage of total land area involved having a complete crown cover.

Cruise—A survey of forest lands to locate and estimate the volume and grades of standing timber. Also, the estimate obtained in such a survey.

Cubic Foot Per Second—See Second Foot.

Current Meter ***(Hydraulics)***—A device for determining the velocity of flowing water by ascertaining the speed at which a stream of water rotates a vane or a wheel.

Cut-off—(1) A wall, collar, or other structure such as a trench filled with relatively impervious material intended to reduce percolation of water along otherwise smooth surfaces, or through porous strata. (2) In river hydraulics, the new and relatively short channel formed when a stream cuts through the neck of an "oxbow" curve. This may be done naturally during a flood or artificially.

Cut-over Forest—A forest in which most or all of the merchantable timber has been cut.

D

Dam—A barrier to confine or raise water for storage or diversion, to create an hydraulic head, to prevent gully erosion, or for retention of soil, rock or other debris.

Darcy's Equation — A formula for flow (laminar) through porous media; flow of water through soil.

$$Q = KSA$$

where Q is quantity of discharge per unit time; K is a coefficient of permeability of the material; S the hydraulic gradient; and A the cross-sectional area through which water flows.

Datum *(Engineering)*—Plane of reference for elevations.

Dealkalization—Removal of alkali from the soil, usually by leaching.

Debris *(Geology)*—The material resulting from the decay and disintegration of rocks. It may occur in the place where it was produced, or it may be transported by streams of water or ice and deposited in other localities. Syn. *Rock Waste* or *Detritus*.

Debris Cone *(Geology)*—A fan-shaped deposit of soil, sand, gravel, and boulders built up at the point where a mountain stream meets a valley, or otherwise where its velocity is reduced sufficiently to cause such deposits. Similar to alluvial fan, but consists of coarser material lying on steeper slopes.

Debris Dam—A barrier built across a stream channel to store rock, sand, gravel, silt or other material like driftwood.

Deciduous Plant—A plant which sheds all its leaves every year at a certain season.

Deferred Grazing—The postponement of the use of grazing lands from the start of forage growth until a definite stage of plant development has been reached. Contrast with *Continuous Grazing; Rotation Grazing*.

Deficiency—The amount by which a series of quantities falls short of a given demand, normal, or other criterion; the opposite of an excess. Frequently used in reference to rainfall, temperature, and other meteorological and hydrological quantities. Also used in reference to mineral elements essential to plant growth or animal life.

Deflocculation — The separation or break down of soil aggregates containing clay into their individual particles.

Delivery Box *(Irrigation)*—A structure for the control and proportionment of water delivered to farm units.

Delta—An alluvial deposit formed where a stream or river drops its sediment load on entering a body of more quiet water, formed largely beneath the water surface, and often resembling the shape of the Greek letter Delta.

Demonstration Area *(Soil Conservation Service)*—A section of country, usually a small watershed set aside and designated by name and number, on which demonstrational work in soil and water conservation and land use was done by and between the Soil Conservation Service and the farmers. Demonstration areas were in operation from September 1933 to 1943. Also known as *Watershed Demonstration Project; Soil and Water Conservation Demonstration*.

Dental — A tooth-like projection on an apron, or other surfaces to deflect or break the force of flowing water; a form of baffle.

Dentated Sill—A notched sill at the end of an apron to check the force of flowing water and thus reduce erosion below the apron.

Dependency Zone *(Range)* — A specific area surrounding certain private lands, within which use of private range land may be supplemented by use of public land.

Dependent Property *(Range)*—Privately owned or controlled land or water deemed to have special claims for companionate use with certain public or cooperatively controlled range land.

Depletion Curve *(Hydraulics)*—A graph representing the rate of water flow or seepage from ground water storage into stream channels.

Deposition — The accumulation of soil material dropped because of slackening movement of the transporting agent—water or wind. Accumulation at the foot of an eroded slope, alluvial fans and dunes are examples of deposition.

Depth, Effective Soil—The depth of soil material which plant roots can penetrate readily to obtain water and plant nutrients. It is the depth to a layer that differs from the overlying material in physical or chemical properties sufficiently to prevent or seriously retard the growth of roots.

Desalinization—Removal of salts from saline soil, usually by leaching.

Desert—An area with an extremely arid climate. Vegetation, if present at all, is generally sparse and includes very hardy, drought resistant types such as cactus and rapid-growing annuals that can grow, bloom, and produce seed on the moisture from a single good rain or a brief rainy period.

Desilting Area—An area of grass, shrubs or other vegetation used solely for deposition of silt and other debris from flowing water, located above a stock tank, pond, field or other area needing protection from sediment accumulation. See *Filter Strip*.

Desilting Basin—See Settling Basin.

Detachment *(Soil Erosion)*—The removal from a soil mass of transportable fragments of soil material by an eroding agent, usually falling raindrops, running water, or wind. Through detachment, soil particles or aggregates are made ready for transport. See *Transportation*.

Detention Dam—A dam constructed for the purpose of temporary storage of streamflow, or surface runoff, and for releasing the stored water at controlled rates.

Deviation, Standard *(Statistics)*—A measure of the average variation of a series of observations or items of a population about their mean. In normally distributed sets of moderate size, the interval of the mean plus or minus the standard deviation includes about ⅔ of the items.

Diameter Breast High—The diameter of a tree 4.5 feet above average ground level. Abbr. *D.B.H.*

Dibble—A tool for making holes for planting seeds or young trees. Syn. *Planting Bar; Spud.*

Dike—An embankment to confine or control water, especially one built along the banks of a river to prevent overflow of lowlands; a levee.

Discharge *(Hydraulics)*—The quantity of water, silt, or other mobile substances passing along a conduit per unit of time; rate of flow; cubic feet per second; liters per second; gallons per minute.

Discharge Coefficient *(Hydraulics)*—The ratio of actual rate of flow to the theoretical rate through orifices, weirs, or other hydraulic structures.

Disclimax *(Ecology)*—A climax which is modified by disturbance of the natural succession by man or domestic animals. Syn. *Disturbance Climax.*

Dispersion, Soil—The breaking down of soil aggregates, resulting in single grain structure. Ease of dispersion is an important factor influencing the erodibility of soils. Generally speaking, the more easily dispersed the soil, the more erodible it is.

Dispersion Ratio—The ratio of silt plus clay remaining in suspension after limited shaking and settling, using specific procedure, to the total silt plus clay as determined by mechanical analysis. The greater this ratio, the more easily the soil can be dispersed.

Dissection—The work of erosion in destroying the continuity of a relatively even surface by the cutting of ravines or valleys.

Distributaries *(Irrigation)*—The smaller conduits taking water out of the main canals for delivery to the farms; any system of secondary conduits.

Distribution System *(Irrigation)*—The system of laterals, distributaries, and their appurtenances conveying irrigation water from the source to the farm units. See *Canal, Main Irrigation; Distributaries; Irrigation Lateral; Irrigation Structure.*

Diversion—A diversion is a channel with a supporting ridge on the lower side constructed across the slope to intercept run-off and minimize erosion, or to prevent excess run-off from flowing onto lower lying areas. In some areas a series of diversions are constructed across the slope similar to terraces, but with greater horizontal and vertical spacing. Also known as *Diversion Terrace.*

Diversion Dam—A barrier built to divert part or all of the water from a stream into a different course.

Divisor—A device which effects the continuous separation and diversion of a representative fraction of the run-off from experimental areas. The diverted fraction is weighed or measured and may be analyzed to furnish a basis for calculation of the total losses of soil and water.

Dolomite—A rock containing a high percentage of calcium and magnesium carbonates. Ground dolomitic limestone, containing considerable magnesium carbonate as well as calcium carbonate, is widely used as agricultural lime, especially on soils with a low magnesium content.

Dominant *(Plant Ecology)*—Species which are the controlling and most widespread species within certain prescribed boundaries. They are usually the most abundant, or may be the largest and longest lived. Dominants of climax communities are called *Climax Dominants.*

Drain—A buried pipe or other conduit (closed drain) or a ditch (open drain) for carrying off surplus surface or ground water.

Drainage—(1) The removal of excess surface or ground water from land by means of surface or subsurface drains. (2) The effect of soil characteristics which regulate the ease or rate of natural drainage. Soil is said to be "well drained" when the excess water drains away rapidly and "poorly drained" when excess water drains away so slowly that it interferes seriously with tillage or plant growth.

Drainage Basin—The largest size natural drainage area subdivision of a continent. The United States has been divided at one time or another for various administrative purposes into some 12 to 18 drainage basins or groups of watersheds, such as the Colorado, Missouri, and Columbia basins. See *Watershed.*

Drainage District—A cooperative, self-governing public corporation created under state law to finance, construct, operate, and maintain a drainage system.

Drainage Terrace—A graded terrace built with a relatively deep channel and low ridge primarily for hillside drainage. See *Graded Terrace; Nichols Terrace.*

Draw *(Topography)*—A natural depression or swale; a small natural drainageway.

Draw-down Curve *(Drainage)*—A curve representing the theoretical curvature of the surface of ground water as affected by the removal of ground water by tile, open ditch or other means.

Drift *(Geology)*—Material of any sort deposited in one place after having been moved from another. The term is most commonly used when referring to glacial drift, or material deposited after having been moved by glacial action. Glacial drift includes unstratified glacial deposits, or till, and stratified glacial outwash materials.

Drift Barrier—An open structure built across a stream channel to catch driftwood. It may be of any form from a simple wire fence to a barrier of massive piers with heavy cables strung between them.

Drift Fence *(Range Management)*—Any fence, used by itself or in connection with natural barriers, to prevent stock from drifting from their regular range to another. Such fences seldom form complete enclosures.

Drill Seeding—Planting seeds with a drill in relatively narrow rows, generally less than a foot apart. Contrast with *Broadcast Seeding; Row Crop.*

Driveway, Stock—A strip of country set aside for the specific purpose of movement of livestock from place to place. Examples, from range to shipping point or home ranch; from seasonal range to seasonal range. See *Stock Trail.*

Drop *(Hydraulics)*—A structure for dropping the water in a conduit to a lower level and dissipating its surplus energy; a fall. A drop may be vertical

or inclined; the latter is sometimes called a chute.

Drop Structure—A dam constructed in a gully or other watercourse to lower the grade of the watercourse and thereby decrease the velocity of flow, promote the deposition of sediment, and prevent further channel erosion.

Drop-inlet Dam—A dam with provision for carrying off overflow through a gently sloping pipe under the dam, connected to an open-topped vertical pipe, or riser, at the pond side of the dam. The length of the vertical riser or "drop inlet" is most often 5 to 15 feet, but may be more.

Dry Farming—(1) Farming in semi-arid or arid regions without irrigation. (2) A system of fallow and stubble mulch designed to absorb and retain the precipitation which occurs.

Duckfoot—An implement with horizontally spreading V-shaped tillage blades, or sweeps, which are normally adjusted to provide shallow cultivation without turning over the surface soil or burying surface crop residues.

Duff—The more or less firm organic layer in forests. It consists of fallen vegetative matter in the process of decomposition including everything from pure humus below to the litter on the surface. Duff is a general, non-specific term.

Dune—A mound or ridge of loose sand piled up by the wind; common where sand is abundant and wind usually strong as along lake and sea shores and in some desert and semi-desert areas.

Dune Sand — (1) Areas of wind-drifted sand in dunes, hummocks and ridges, usually free from vegetation and undergoing active erosion and redeposition by winds. (2) Sand, predominantly from 0.1 to 0.4 mm diameter, that has been piled up by wind into dunes.

Duration Curve ***(Hydraulics)*** — A graphical representation of the number of times given quantities are equalled or exceeded during a certain period of record. For example, if in a 10-year record of daily stream flow, the percentage of time the flow was above certain values was plotted against flow, the graph would constitute a duration curve for that stream and period.

Dust Mulch—The loose dry surface layer of a cultivated field; a shallow layer of loose surface soil.

E

Earth Dam—A barrier for confining water composed of earth (clay, silt sand or sand and gravel) or a combination of earth and rock.

Earthflow—See Landslide.

Edge ***(Wildlife)*** — The sharp, terminating border where one cover type ends and another begins.

Effluent—The outflow of water from subterranean storage.

Elevated Ditch ***(Irrigation)***—Earth-fill crossing, constructed to specifications similar to those for earth-fill dams, placed across canyons or other large depressions to provide canal or lateral crossings at normal grade, as a substitute for flumes or siphons. Syn. *Raised Ditch.*

Eluviation—The removal of material from a soil horizon by downward or lateral movement in solution and to a lesser extent in colloidal suspension. Contrast with *Illuviation.*

Energy Head ***(Hydraulics)***—The elevation of the hydraulic grade line at any section plus the velocity head of the mean velocity of the water in that section. The energy head may be referred to any datum, or to an inclined plane, such as the bed of a conduit.

Engineering Practices—Soil and water conservation practices which are primarily designed to change the slope characteristics of land so that the amount and velocity of surface run-off and erosion are reduced; for example, the use of systems or devices for the disposal of excess water such as terraces, contour furrows, diversions, dams, dikes, channels and tile lines. Contrast with *Vegetative Practices.*

Entrance Head—The head required to cause flow into a conduit or other structure; it includes both entrance loss and velocity head.

Environment—The sum total of all the external conditions which may act upon an organism or community, to influence its development or existence. For example, the surrounding air, light, moisture, temperature, wind, soil and other organisms are parts of the environment, or environmental factors.

Eolian Soil Material—See Aeolian Soil Material.

Equalizing Basin ***(Irrigation)***—A small stilling basin from which two or more irrigation furrows receive an equal flow of water.

Erodible ***(Geology and Soils)***—Susceptible to erosion. A soil, for example, that is quite susceptible to erosion is referred to as "erodible," while one that is resistant to erosion is said to be "non-erodible."

Erosion—The detachment and movement of the solid material of the land surface by wind, moving water or ice, and by such processes as landslides and creep. See *Accelerated Erosion; Blowout; Creep, Soil; Detachment; Gully Erosion; Landslide; Mudflow; Normal Erosion; Rill Erosion; Sheet Erosion; Shore Erosion; Slip; Soil Erosion; Splash Erosion; Stream-bank Erosion; Stream-bed Erosion; Transportation; Undercutting; Wind Erosion.*

Erosion Class ***(Soil Conservation Surveys)***—An erosion condition or set of conditions used in mapping the effects of accelerated erosion, or the absence of any effects of it, as part of the land information obtained in a soil conservation survey. An erosion class may consist of a group of similar erosion conditions, such as moderate sheet erosion, or of a characteristic combination of erosion conditions, such as moderate sheet erosion with closely spaced gullies. For convenience in mapping, the classes that designate no apparent erosion, recent alluvial deposits, normal erosion and certain disturbed areas are also commonly called "erosion classes." The erosion class is an appraisal at a specified time of the cumulative effect of accelerated erosion on the area mapped.

Erosion Pavement—A layer of coarse fragments of gravel or stones on the surface of the ground, remaining after the removal of fine particles by erosion.

Erosive—Tending to cause erosion; the term applies to the eroding agent, such as wind or water. The term has also been used interchangeably with "erodible," but the word "erosive" is preferred when referring to the agent causing erosion, and "erodible" when referring to the material eroded.

Error, Standard *(Statistics)*—An estimate of the standard deviation of means of samples drawn from some single population. Often calculated from a single set of samples.

Escape Covert *(Wildlife)*—Vegetation intended or serving as a refuge for animals in hiding from or getting out of reach of enemies.

Essential Element *(Plant Nutrition)*—A chemical element which is required for the normal growth of green plants. These include: the primary essential elements nitrogen (N), phosphorus (P), and potassium (K), the secondary essential elements sulfur (S), calcium (Ca), and magnesium (Mg), and the rarer essential elements, known as *Trace Elements* or *Minor Elements*, iron (Fe), boron (B), manganese (Mn), copper (Cu), zinc (Zn), and molybdenum (Mo). Traces of other elements may be essential or beneficial, at least for some plants. Large amounts of carbon (C), hydrogen (H), and oxygen (O) obtained from the air and water are also necessary for plant growth.

Evaporation—The process of vaporization by which a liquid or solid is changed to a vapor or gas. The evaporation process by which a solid passes directly into the vapor state is called sublimation.

Evapo-Transpiration *(Irrigation)*—Combined loss of water from soils by evaporation and plant transpiration. Syn. *Consumptive Use.*

Exclusion of Livestock—Excluding for at least one 12-month period, all livestock from a designated grazing area for the purpose of forage protection, erosion control, or until a permanent cover of grass or shrubs is established.

Exempt Stock *(Range)*—Stock which are permitted to graze on the National Forests or Public Domain free of charge. Confined to animals actually used for domestic purposes, such as work or saddle horses and milk cows.

Experimental Design—The plan for an experiment, particularly, that part which insures that a statistical method may be used on the resulting data.

F

Factor, Limiting—The substance or condition which is least available and which because of its unavailability determines the extent of a life process in a plant is called the limiting factor. For example, growth may be limited by moisture, by temperature, by aeration of the soil or the amount of some essential element available in the soil. These factors or conditions are seldom independent. Usually a change in one condition will result in changes in others.

Fallow—Allowing crop land to lie idle either tilled or untilled during the whole or greater portion of the growing season. Tillage is usually practiced to control weeds and encourage the storage of moisture in the soil. See *Summer Fallow.*

Farm Management—The organization and administration of the farm resources including land, labor, crops, livestock and equipment.

Farm or Ranch Conservation Plan—A statement of objectives for the conservation and management of the land on a given farm or ranch, together with a course of action to achieve them, supported by inventory data and analysis. The plan may consist of written, tabular and graphic parts.

Farm Pond—A small body of water retained behind a dam or held in a hole dug in the ground; of lesser area than a lake. See *Tank, Earth.*

Farm Waterway—A natural or constructed waterway which is entirely within an individual farm boundary.

Fauna—All the wild animals living in a given area, or within a stated period of time.

Fee *(Range)*—A charge made for livestock grazing on the basis of a certain rate per head for a certain period of time.

Feed—Harvested forage such as hay or fodder or grain, grain products and other foodstuffs processed for feeding livestock.

Fertility, Soil—The presence in a soil of the necessary elements, in sufficient amounts, in the proper balance and available for the growth of specified plants, when other factors, such as light, temperature, and the physical condition of the soil, are favorable.

Fertilizer—Any material which is added to the soil to supply one or more of the plant nutrients.

Fertilizer, Commercial—Any industrial raw or processed material used to fertilize the soil. Includes such organic products as milorganite, but not barnyard manure.

Fertilizer Analysis—The percentage composition of a fertilizer, expressed in terms of nitrogen, phosphoric acid, and potash. For example, a fertilizer whose analysis is "6-12-6" contains 6% nitrogen (N), 12% available phosphoric acid (P_2O_5), and 6% water-soluble potash (K_2O).

Fertilizer Formula—The quantity and grade of the crude stock materials used in making a fertilizer mixture. For example, one formula for a fertilizer whose analysis is 5-10-5 could be 625 pounds 16% nitrate of soda, 1111 pounds of 18% superphosphate, 200 pounds 50% muriate of potash, and 64 pounds of filler per ton.

Fertilizer Grade—A term used to indicate the number of units of plant food contained in one ton of a given fertilizer.

Fertilizer Unit—One per cent of a ton of fertilizer, or 20 pounds. For example, a 5-10-5 fertilizer contains 5 units (100 lbs.) of nitrogen (N), 10 units (200 lbs.) of available phosphoric acid (P_2O_5), and 5 units (100 lbs.) of water-soluble potash (K_2O).

Fibrous Root System—A plant root system having a large number of small, finely divided, widely spreading roots but no large individual roots. Typified by grass root system. Contrast with *Tap Root System.*

Field Border Plantings—Vegetation established on field borders to conserve soil and provide cover and

food for wildlife.

Field Capacity *(Soils)*—The moisture content of a soil, expressed as percentage oven-dry weight, after the gravitational or free water has been allowed to drain, usually for two to three days. The field moisture content two or three days after a soaking rain. Also known as *Field Moisture Capacity; Field-Carrying Capacity; Normal Field Capacity; Normal Moisture Capacity; Capillary Capacity.*

Field Crops—General grain, hay, root and fiber crops as contrasted with truck (vegetable) and fruit crops.

Field Plantings *(Soil and Water Conservation)*—The establishment of woody plants on land essentially free of trees. Includes woody plantings for the protection of critical slopes, stabilization of spoil banks, sand dunes, etc., and plantings for production of wood crops.

Field Strip Cropping—A system of strip cropping in which crops are grown in parallel sided strips laid out across the general slope but which do not follow the contour. Strips of grass or close growing crops are alternated with those in cultivated crops.

Field Test — An experiment conducted under field conditions. Ordinarily less subject to control than a formal experiment and may be less precise. Syn. *Field Trial.*

Filter Strip—A strip of permanent vegetation of sufficient width and vegetative density above farm ponds, diversion terraces and other structures to retard flow of run-off water, causing it to deposit soil, thereby preventing silting of structure or reservoir below.

Fine Textured Soil—A soil predominately silt and clay.

Fire Control Line—In forestry, the line used either directly to stop the advance of a fire or the line from which to backfire.

Fire Danger Station—A location where the variable factors of forest fire danger are determined daily.

Fire Hazard—In forestry, the risk or danger of loss or damage from burning due to the presence of inflammable material together with probable source of fire origin.

Firebreak—In forestry, an existing barrier, or one constructed before a fire occurs, from which inflammable materials have been removed, designed to stop or check creeping or running fires. Also serves as a line from which to work and to facilitate the movement of men and equipment in fire suppression.

Firebreak, Burned—In forestry, a firebreak in which the inflammable material has been removed by burning.

First Bottom—The normal flood plain of a stream. Some first bottom areas are flooded frequently, others at less frequent intervals. The term "high bottom phase" is commonly applied to areas which rarely flood. See *Flood Plain.*

Fish Pond Management—The art of creating a pond environment suitable for fish production, and manipulating fish populations to make them most useful to man. Many include fertilization and the control of undesirable pond weeds.

Fish Screen—A barrier placed across the inlet or outlet of a pond to prevent the passage of fish.

Fishway—A sloping structure designed to enable fish to ascend a cataract or dam; a fish ladder.

Flashboard—A plank, usually of timber and generally held horizontally by end girders or by other supports, in a slot, on the crest of a dam or check structure, or in a spillway, to control the water level. Syn. *Stop-log; Stop-plank.* See *Needle.*

Float Gaging—Measurement of stream discharge by determining the velocity of a float placed in the flowing water.

Flocculation—The grouping together or coagulation of suspended colloidal or very fine particles into larger masses or floccules which will eventually settle out of suspension. Flocculation may aid in the formation of soil aggregates, but it is not identical with aggregation in soils. The process opposite to flocculation is called deflocculation or dispersion.

Flood Coefficient *(Hydraulics)*—A numerical expression of the proportion of the pluviagraph run-off that actually occurs as surface run-off, expressed as a decimal; the per cent run-off obtained by dividing the pluviagraph run-off by the actual surface run-off. See *Pluviagraph.*

Flood Plain—Nearly level land occupying the bottom of the valley of a present stream and subject to flooding, unless protected artificially.

Flood-Gate—A gate placed in a channel to keep out flood or tidal water. See *Tilting Gate.*

Floodwater Retarding Structure—A dam across a small stream or other watercourse usually designed with an uncontrolled outlet so that it will temporarily impound runoff from the watershed above and release it at a rate which will prevent channel overflow below the dam, thereby retarding and decreasing the discharge of flood flows.

Floodway—A channel, usually bounded by levees, used to carry flood flows.

Flora—The species of plants growing without cultivation in a given area, or within a stated period of time.

Flowage Line *(Hydraulics)*—A contour line around a reservoir, pond, lake, or the water surface-line along a stream, corresponding to some definite water level (maximum, mean, low or spillway crest). Generally used in connection with the acquisition of rights to flood lands for storage purposes. Syn. *Flow-line.*

Flume—An open conduit of wood, concrete, stone or metal on a prepared grade, trestle, or bridge for the purpose of carrying water or other liquids across creeks, gullies, ravines, or other areas which lie along a canal or ditch location. It may also apply to an entire canal where it is elevated above natural ground for its entire length.

Fodder—The dried, cured plants of tall, coarse, grain crops such as corn and sorghum, including the grain, stems, and leaves. Grain parts not snapped off or threshed. Contrast with *Stover; Hay.*

Food Chain *(Biology)*—A series of plant or animal species in a community, each of which is related to the next as a source of food.

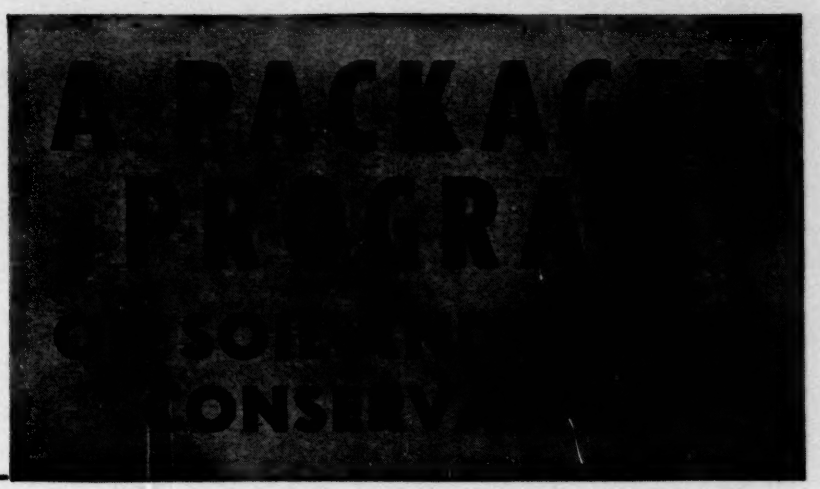
(Continued in the April Issue)

Free . . . to

INSTRUCTORS

CLUB LEADERS

FARM ADVISORS



8 MOVIES

. . . 16 mm. in full color and sound. "Soil and Life" tells the whys and hows of conservation. "Strips and Curves"— erosion control on the Great Plains. Other titles: "Water Spreading," "Modern Farm Machines Bring Back the Range," "Broad Base Terracing," "Build Good Terraces," "Level Farming on Sloping Fields," "Building a Pond."

8 BOOKLETS

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